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POWER

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Power & Mining Machinery Co.

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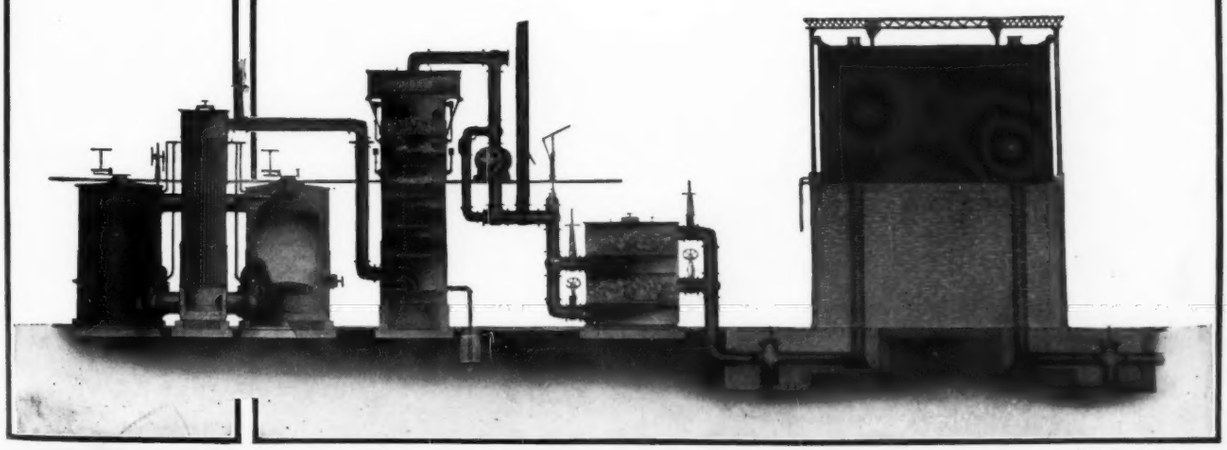

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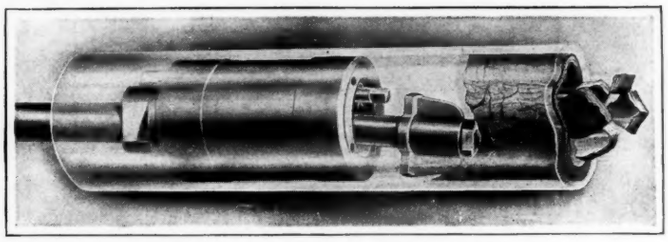

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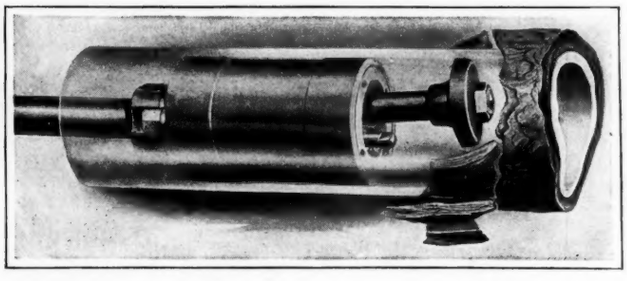


The Dean Removing Scale from the Tube of a Return Tubular Boiler.

POWER

NEW YORK, APRIL 25, 1911

THERE is probably more attention, intelligent and otherwise, being given to the boiler room of the modern power plant today than to any other one department.

In the production of power the cost of the fuel is in most cases the largest single item in the expense account, and any percentage of reduction in this means more than an equivalent saving made in any other way.

Power plants are operated for the profit there is in the business, and any plan or suggestion that seems to point toward a possibility of increase in profits will be given more or less consideration by the man or men most directly interested.

It, however, seems strange that men who use good business judgment in every other department of their business are so indifferent to the results obtained in the burning of fuel.

In chemical industries certain materials are changed from one form to another. Measured quantities of different substances are mixed or treated with known weights or measures of still other materials for the purpose of enhancing their value to mankind. The results are accurately observed and any departure from uniformity is made the subject of special investigation.

Untrained and careless men are not given responsible positions in such industries because it does not pay to employ men who are potentially wasteful. The product costs money and carelessness or ignorance on the part of one man may possibly waste the wages of many in inferior product or restricted production.

The burning of coal, wood, gas, oil or any other fuel in a boiler furnace is a chemical process on a commercial scale. It is industrial chemistry.

Air, carbon and hydrocarbons are mixed and the product goes up the chimney. But the fact that the product is wasted and that the provisions for wasting the product mean an investment does not lessen the importance of knowing the ratios of the elements in this waste to each other, nor the value of the ability to keep this ratio constant and at its best.

Too much air cools the furnace; too little wastes the fuel by poor combustion; too thick a fire restricts the draft and hinders combustion, and too thin a fire may have holes and will pass too much air anyway.

What is wanted is such a mixture of air and burning fuel that the highest possible percentage of carbonic acid gas will be held in the gases which go up the chimney.

Expert firemen are industrial chemists of no small degree of skill, and the plant manager who fails to recognize this and secure the best in preference to ordinary unskilled labor, whatever may be the difference in labor market rates, is standing in his own light.

What is wasted by an untrained, careless fireman will, if saved, in most plants more than pay the wages of the highest priced man about the establishment.

The Coal Problem Analyzed

By A. Bement

In which attention is given to the proper usage of significant coal terms, the analysis of coal, its size, the ash content, and features over which the producer has control. A number of illustrations of trouble frequently met with in the burning of coal are also given.

Under this title an attempt will be made to discuss certain features of coal and its utilization, and it is believed that the following may be of assistance toward a better understanding of a difficult and complicated problem.

Attention will be first directed to the matter of definition of words and terms, as there is no agreement in the use of them, neither is there a sufficient accepted vocabulary to enable one to give clear and definite expression to his meanings. This leads to various people using the same word or term in a variety of ways and for the purpose of indicating things of different character. Therefore, in the following, attention is directed to certain terms which have special significance.

Terms of Special Significance

Coal: There is no definite agreement as to what is implied by the use of this word, whether it refers to the coal itself or to the fuel mixture. According to the best defined meaning, coal is a solid fuel and it is something which enters combustion and produces heat. Therefore, none of its components can be ash or moisture, because neither of these take part in the combustion process nor do they develop heat. It therefore follows that coal is that part of the fuel minus ash and moisture, sometimes known as ash- and moisture-free coal, for which the term pure coal has been devised. Thus the first equation of Table 1 illustrates the

TABLE 1. ULTIMATE COMPOSITION OF COAL.

Pure coal = Carbon, Hydrogen, Sulphur + Water of Combination, Nitrogen.

Dry Coal = Pure Coal + Ash.

Moist Coal = Dry Coal + Moisture.

composition of coal proper, in other words, pure coal, and the second and third portions show the dry and moist fuel mixtures. It is, of course, true that only carbon, hydrogen and sulphur take part in the combustion process developing heat, so it might appear that water of combination and nitrogen are not constituents of the coal. But there should be no conception of coal, strictly speaking, other than in its chemical aggregate, thus nitrogen and water of combination cannot be considered independent from the coal without implying a destruction of its chemical aggregate. The view that coal fuel is composed of an aggregate of coal, ash and moisture is a definite one, having undisputed application in practice, for it is known that the moisture is immediately evaporated from the mixture because this fact is observed in the laboratory. It is also a fact that the ash is found on the fire grate or in the ash-pit after the coal has been burned. Therefore, it is desirable to consider that coal, according to a strict definition, is that portion of the fuel which is neither moisture nor ash. Thus, it is well, in making use of the word coal to avoid misapplication. In certain instances it must necessarily be used to a great extent as a general term, but when a specific statement is involved it is desirable to adopt a more exact definition. The matter is further illustrated by Table 2.

TABLE 2. PROXIMATE COMPOSITION OF COAL.

Pure Coal = Combustible Elements + Noncombustible Elements.

Dry Coal = Pure Coal + Mineral Matter.

Moist Coal = Dry Coal + Water.

Pure Coal: This is a convenient term which has been quite extensively used to denote that portion of the fuel mixture which is coal, as discussed above. It means the same thing as ash- and moisture-free, but is a more convenient expression.

Fuel Mixture: By this is meant the aggregation of coal, ash and moisture. The acceptance of such a definition is desirable because it tends to avoid confusion and misunderstanding. For illustration, assume that two different lots of fuel are derived from a single coal seam, from the same coal mine, if you will. One is carefully prepared, low in ash; it may be referred to as good coal. Another lot, high in ash and dirty, will be referred to as bad coal, when, as a matter of fact, the coal in each case is absolutely the same. The trouble is entirely apart from the coal and one which concerns the fuel mixture. Yet, the impression conveyed is that the coal itself is of poor quality, not realizing that the trouble is with the larger amount of ash which makes an unsatisfactory fuel mixture. The equations of Table 3 serve to illustrate this feature.

Clean Coal: Properly prepared lump coal, for example, consisting of fuel in which there is no visible ash, or, in other words, consisting of clean, black pieces, accompanied by no slate or other dirt, is very often referred to as pure coal, the inference being that there are no visible impurities with it. This, however, is not a good definition, because ash, although not visible, is one of the components of the lumps. Therefore, the coal is not pure. It contains ash combined in the structure, notwithstanding the fact that it may not be accompanied by pieces of rock or slate. Thus, the expression, clean coal, is a more definite and exact one.

Dirty Coal: An expression often used to denote a fuel mixture containing a large amount of fine fuel, as "slack" or "duff." But is not accurate because these very small pieces of coal are coal to just the same extent as the larger pieces. This term should only be used as applying to a fuel mixture containing foreign matter such as rock, slate, fire clay, etc.

Size: Is, with some fuel, a feature which requires more recognition than it receives, because the size of the pieces have an important influence on the value of fuel coal, as will later appear.

Kind of Coal: This expression is often used with no definite application. The following examples will serve to suggest appropriate application: Anthracite, semi-anthracite, bituminous, semi-bituminous, subbituminous, lignite, coking coal, gas coal, blacksmith's coal, gas-producer coal, pure coal, unit coal, dry coal and moist coal.

Grade of Coal: Thus, it appears from the foregoing that anthracite or bituminous, for example, are not grades, but kinds. The application of the term grade is shown by the following examples: Mine-run, lump, egg, range, nut, buck-

TABLE 3. COMPOSITION OF THE FUEL MIXTURE.

Coal (Pure) = Fixed Carbon, Volatile Combustible, Sulphur + Water of Combin't'n, Nitrogen.

Dry Fuel Mixture = Coal + Ash.

Moist Fuel Mixture = Dry Fuel Mixture + Water.

wheat, raw screenings, slack, washed coal, washed screenings, washed slack and washed nut.

Interpretation of the Analysis

This is a feature of the coal problem in which there is confusion, not only of understanding but of expression. In the usual laboratory treatment, coal is considered as an unknown substance to be analyzed, and the results reported in the terms of the entire weight of the sample, in other words, in terms of the moist-fuel mixture. Thus, for example, a chemist may report the percentage of volatile matter as being less in one sample than in another, the inference being that the two samples, as far as the coal itself (the pure coal), is concerned, differ,

when in fact the coal in each sample may be identical, the difference on the moist-coal basis being due to a greater or less percentage of ash or moisture in the fuel mixture. Thus for the quantitative analysis of the constituents of the pure coal, or, in other words, the real coal, to be comparable one with another, they should be stated on a pure-coal basis.

TABLE 4. CLASSIFICATION OF COMPONENT PARTS OF AN ASSUMED COAL FUEL MIXTURE.

Combustible Elements in Coal.		Noncombustible Constituents Chemically Combined with Coal.		Noncombustible Constituents in a Physical Combination with Coal.	
Carbon	61.0	Water of Combina'tn	8.2	Moisture	12.0
Hydrogen	3.3	Nitrogen	1.1	Ash	11.4
Sulphur	3.0				
Totals	67.3		9.3		23.4

Combustibles	67.3
Chemical noncombustibles	9.3
Physical noncombustibles	23.4
Total	100.0

This reasoning applies to the ash constituent of the fuel mixture, because, if expressed on a moist-fuel basis, it will appear as a variable depending on the amount of moisture present. For this reason the amount of the dry, not the moist ash, is the significant quantity. Thus it is necessary to consider the object required. It is true, of course, that the proper measure of heating value of coal, as bought and sold in commerce, is expressed on a moist-coal basis, because it is the moist-coal fuel mixture that is bought and sold. No mine produces dry or pure coal. Ash and dirt, as well as moisture, always accompany it, but if it is desirable to know whether the ash content of one fuel mixture is greater or less than another, the values must be reduced to a dry-coal basis, and if desirable to make comparison between the coal of two or more fuel mixtures, heat value must be given in terms of the pure coal.

TABLE 5. RELATIVE COMPOSITION OF AN ASSUMED FUEL MIXTURE.

Constituent.	Chemical Symbol.	Per Cent.	Character.
Carbon	C	61.0	combustible
Hydrogen	H	3.3	combustible
Sulphur	S	3.0	combustible
Moisture	H_2O	12.0	noncombustible
Water of combination	H_2O	8.2	noncombustible
Nitrogen	N	1.1	noncombustible
Ash		11.4	noncombustible
Total		100.0	

In the application of the analytical data to the use of fuel in connection with its combustion, in fires under boilers, for example, it is an assistance to consider the matter from its actual relation to the process. In this connection, Tables 4, 5, 6 and 7, will be of service.

Table 4 presents the fuel mixture in three groups, illustrating the relation of the combustible and noncombustible elements. In Table 5 is shown a quantitative classification of constituents. Table 6 illustrates the combustion process and disposal of the products of combustion.

In applying analytical data to problems in practice, it is desirable to simplify the matter as much as possible. Thus in the foregoing, it appears that the entire hydrogen content is not treated as combustible, yet it is so given in the results of practically all ultimate analyses which have been reported up to the present time. But, according to our conception of the matter, oxygen must necessarily be chemically combined with some other element, and the assumption that this combination is with hydrogen, is the most reasonable one. Therefore, all of the oxygen of the coal is combined with hydrogen, so it must enter the combustion process as H_2O and leaves it in the same condition. For this reason, in calculating a heat balance, it is not only undesirable to consider this water as separate elements of hydrogen and oxygen, but doing so leads to confusion if the standard code for steam-boiler trials of

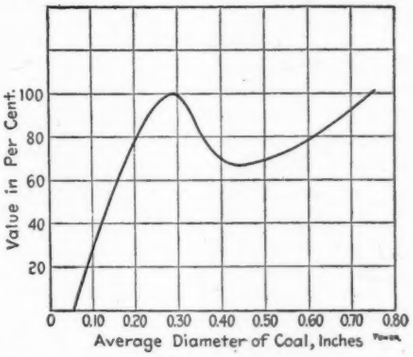


FIG. 1. CURVE SHOWING RELATIVE VALUE OF 1¼-INCH SCREENINGS AS EFFECTED BY SIZE OF PIECES

the American Society of Mechanical Engineers is followed, because in it air supply is figured for the total hydrogen instead of only that portion available for combustion. Thus, we have two different conditions of water in the fuel mixture, one in the coal itself, which is liberated by the combustion process, and the other in a free condition, which is dispelled as soon as the coal is heated and before combustion begins.

CONSIDERATION OF THE SIZE

To the present time fuel coal has been valued entirely upon the basis of its chemical analysis and price. It has, however, been observed that there are two other very significant features which may have even greater influence than that of chemical composition. One of these is size of the pieces, the other the ash content. For example, assuming that best coal fuel has a heat value of 15,000 B.t.u. and the poorest 9000, the ratios are as one is to 1.66. It has been found, however, that in practical conditions of operation, coal may be of so small size as to give a zero result in use, in other words, to have no value whatever, or again, of such large size, that the practical value of the fuel is largely reduced, yet the results of analysis might be the same in each instance.

This matter is illustrated by Fig. 1,

TABLE 6. COMBUSTION PROCESS.

As Entering Combustion.	Result of Combustion.	Character and Disposal of Products.
Carbon	CO_2	Gas to chimney.
Hydrogen	H_2O	Steam to chimney.
Sulphur	SO_2	Gas to chimney.
Moisture (H_2O)	H_2O	Steam to chimney.
Water of combination (H_2O)	H_2O	Steam to chimney.
Nitrogen	N	Gas to chimney.
Ash	Ash and clinker	Ash and clinker to the ashpit.

showing the value of stoker fuel for steam boilers. It shows very plainly that the feature of size is one of great significance. An explanation for the formation of the curve is that, as the average diameter of the pieces increases, a point is reached at about 0.28 inch where the amount of dust and small pieces is just sufficient to properly fill the spaces between the larger pieces, after which time the decreasing percentage of small size causes enlargement of the vacant spaces in the fuel bed, with a result that the value decreases rapidly until at about size 0.43 where the average diameter of the pieces has become great enough to insure that in a measure they fit together in harmonious compact. As the average diameter still increases this condition develops, so that at size 0.75 it has again attained maximum value. In other words, the uniformity in size approaches that of nut coal, forming a desirable fuel bed, although if absolutely uniform, the fuel would have a much greater value than illustrated by the curve of the diagram, which is confined to 1¼-inch screenings. The value assumed as 100 per cent. illustrates the best attainment from 1¼-inch screenings. Upon this basis it is apparent that factors may be devised by the use of which the value of fuel may be determined by calculation. For example, if the average diameter should be 0.10 inch, multiplying the heat value by 0.25 would give the actual value, or, if the size is 0.29 inch, multiplying the heat value by 1 would leave it unchanged.

TABLE 7. FORMS OF ULTIMATE ANALYSIS OF AN ASSUMED COMPOSITION.

	As Usually Stated.	As Employed in Practice.
Carbon	79.65	79.65
Hydrogen	5.49	
Available hydrogen		4.30
Oxygen	9.52	
Water of combination		10.71
Nitrogen	1.43	1.43
Sulphur	3.91	3.91
Totals	100.00	100.00

Variation in thickness of fire with me-

chanical stokers is a matter which in itself has an important influence, and values such as those shown by the curve would be more or less modified by adjustment of the fire-bed thickness, or, should hand firing prevail, the result may be influenced through a wide range, by skilful hand manipulation. Thus, fine dust, which would not make a useful fire with a stoker, could be placed in a hand-operated fire, either by sprinkling it lightly over the surface or by allowing it to become coked and then broken up. The tests from which the curve is plotted were all made with one thickness of fire, and uniformity of conditions, except that of the fuel itself. Thus the foregoing shows that the feature of size is of greatest significance as affecting value, especially so, if auxiliary influences, such as hand manipulation, are not employed.

Consideration of the Ash

According to the conception that coal fuel is composed of an aggregate of coal proper (pure coal), ash and moisture, it is found that the coal may differ in quality, due to a greater or less amount of water of combination, sulphur or nitro-

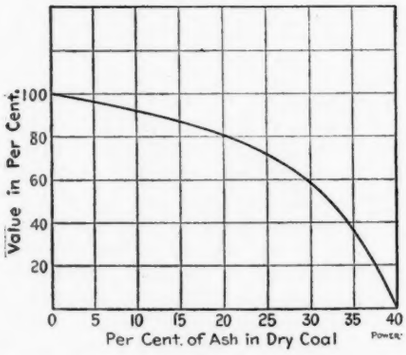


Fig. 2. Value of Coal as Effected by Ash Content

gen. These influence its heat value and in slight measure the loss of heat in the chimney gases, but do not affect or interfere with the combustion process. Neither does the presence of the moisture affect combustion except to cause a lower initial temperature and to increase loss in the escaping gases. Thus the water of combination and the moisture pass freely to the chimney and in no way obstruct action of the fire. With the ash, however, the case is quite different, as it remains as a solid residue, which does obstruct combustion to a very serious extent, as shown by Fig. 2, which, according to best present knowledge, illustrates the effect of ash content for any kind or grade of fuel. From this curve it is possible to devise a set of factors which will compensate for various ash content. Thus, if ash percentage is 20, multiplying the heat value by 0.79 determines the actual value.

A definite and clear conception of the ash with its relation to the fuel mixture is useful. To this end Table 8 gives ash content in three groups.

Referring to the first group, it is known that when a lump of clean black coal, having no visible evidence of ash associated with it, is burned, a residue al-

TABLE 8. ASH GROUPS IN COAL FUEL.

1. Ash in the coal itself.
2. Ash in the coal seam distinct from that in the clean coal.
3. Ash associated with the fuel which becomes mixed with it during mining, but not derived from the seam.

ways remains. This is the ash in the clean coal. In all coal seams distinct stratas of rock, slate, pyrites, etc., prevail to a greater or less extent, as well as impurities, in other than stratified form. These impurities of the seam are distinct from the impurities actually associated with the coal itself. In addition to the impurities of the second division, there are others which emanate from a source entirely outside of and distinct from the seam, such as from the roof and floor of the mine, in the form of fire clay, rock, etc., the matter being further illustrated by the equations of Table 9.

It will be observed in the foregoing that ash is considered as being only the residue remaining after combustion. It is a fact that certain ingredients of the ash mixture, such as fire clay, for example, contain volatile components, as water of combination. Thus, the true ash is the residual quantity, plus the volatile amount. This is true as far as it affects the displacement of pure coal in the fuel mixture. It, however, has no application in practice because it is the residue only which interferes with and affects the combustion process.

Upon the basis of values as displayed by Figs. 1 and 2, Table 10 has been prepared showing values in 1¼-inch coal screenings for maximum ranges of size and ash content. It is, however, not implied that 1¼-inch screenings may be as small as an average diameter of 0.06 inch, but the range has been carried thus far for purposes of illustration.

Relation of the Producer and Coal Users to the Problem

Within recent years it has become customary to purchase coal under specification, with an agreement as to quality, with bonus or penalty in case the fuel delivered is superior or inferior to the requirements. Many difficulties, however, have been encountered owing to the complications involved. Probably the matter may be illustrated by quoting what somebody is supposed to have said, "that it is not so bad to be ignorant, as it is to know so many things which are not true." This very aptly illustrates the position of the coal consumer. On the other hand there exists an equal lack of positive knowledge on the part of the coal producer and dealer. The relation of producer and consumer to the problem will be better understood when the manner is explained by which the producer may fail to furnish proper fuel. When the matter has been analyzed, it appears that the features over which the producer has control as affecting the quality of the fuel, are as follows:

Features over Which Coal Producer Has Control

1. Locality and seam from which the fuel is taken.
2. Size of the pieces of the fuel.
3. Amount of the ash content.

It may appear strange that the producers' power is so limited when many specifications give much prominence to volatile matter, sulphur, fixed carbon, heat value, etc. But when the matter is duly considered, the facts become apparent; for example, it is now well known that a particular coal seam or definite locality in a seam is of a constant and uniform quality, as far as the coal itself is concerned. Therefore, this being true, it follows that fixed carbon, volatile matter, sulphur or other components are constants and need only be determined once. It also follows that the composition would be the same from any mine.

TABLE 9. DETAIL GROUPING OF ASH CONTENT.

Group.	
No. 1.	= Ash in clean coal.
No. 2.	= Ash of group No. 1 + the distinct impurities derived from the seam.
No. 3.	= Ash of group No. 2 + dirt and rock.

Thus, if the coal is taken from the proper locality or seam, the requirements are automatically satisfied.

The size of the pieces in which the fuel is produced is a matter of great importance in certain coal districts. In others where only mine-run coal, owing to its friable nature, is produced, the consideration of size is entirely eliminated, as all of the fuel as hoisted out of the mine is loaded directly into railway cars. With the fuel, however, which is graded into various sizes, a more or less elaborate screening process is employed. Thus the producer has control over the sizes furnished.

The amount of ash content in the fuel is dependent largely upon the care exercised in mining, which consists in removing dirt and pieces of rock from the fuel mixture and in provision to prevent dirt becoming mixed with the coal. This is one of the important features of the preparation of fuel.

Other features which are often considered by coal consumers as something over which the producer has control, but which he really is unable to exercise any influence, are as follows:

Features over Which the Coal Producer Has No Control

(1) Moisture content, (2) heat value, (3) fixed carbon, (4) volatile matter, (5) sulphur, (6) evaporative perform-

ance secured in use of the fuel, (7) amount of smoke that may be produced, (8) suitability.

Referring to these features in detail, the moisture content, for example, is a constant of the coal seam and is the result of natural processes, extending over ages, during the time the coal was formed. The coal miner cannot afford to dry the coal by artificial means before shipment, neither would it be profitable as a general practice to add water to it, thus moisture is constant until changed by weather conditions, or time in transit. The heat value, fixed carbon, volatile matter and sulphur are likewise constants of the coal which cannot be changed. For illustration, it would be impracticable for a coal producer to make a change in the sulphur content. There is no method by which it may be reduced and it would not be profitable to add sulphur as an adulterant because it costs very much more than coal.

If a purchaser or consumer should demand coal from a prescribed locality, specifying heat value of the fuel mixture, and the heat value of the coal delivered did not meet the specifications, it would either be caused by excessive ash content, substitution from some other locality, or that the specification of heat value did not apply. It would not be because the producer did anything to alter the heat value and the same is true of any constituent of the pure coal.

The matter of the amount of water which may be evaporated when coal is burned under boilers is a matter around which more confusion, trouble and uncertainty has centered than probably anything else. This is because there are so many factors having influence that it is impossible usually to know whether the result was due to the fuel, the character of manipulation it received, or to the efficiency of the steam-generating apparatus in which it was employed.

Under the heading of what is designated as suitability a large variety of demands are made regarding the performance of fuel which have no reasonable application, as will be shown in the following six examples of cases which have actually occurred. These cases are quoted as illustrating troubles as they often appear when the causes are not well understood.

Coal of Too Large Size in Hand Firing

An important power producer had successfully operated a down-draft type of furnace for a number of years, but one day some new coal was received with which it seemed impossible to maintain the usual steam pressures. When the trouble was investigated, the engineer stated that the coal "appeared to be all right but that there was no heat in it." Screenings were the fuel which had been regularly employed, but owing to an emergency, it was necessary to accept anything obtainable, which happened to be some very high-quality lump coal; in fact a very much superior fuel to that which had before been satisfactorily employed.

The trouble was that a sufficiently deep fuel bed was not maintained. With the screenings, being of a small size, a comparatively thin bed was sufficient to exclude excessive air supply. But with the lump coal, the fireman followed previous practice as to thickness of fuel bed, with a result that so much air flowed between the pieces of the burning coal that the heat generated was almost entirely expended in heating this air and for this reason there was very little left to make steam in the boilers, or, in other words, nearly all of the heat went up the chimney. This fact, however, not being realized, it was thought the trouble was due to some mysterious characteristic of the coal.

Thin Fuel Bed

Complaint in a certain instance was made of a high quality of washed nut coal being used on a mechanical stoker. The report was that the coal would not burn. The coal company supplying the fuel sent its trouble man to investigate. He returned with the statement that the coal looked all right; it was clean, bright and accurate as to size, but that it would not burn. He had watched the performance himself. The only explanation offered was that, for some unknown reason, the particular lot of coal was of such peculiar chemical quality that it could not be ignited. The fact was that the fuel bed on the stoker grate was too thin, allowing such a great excess of air to flow through, that the temperature was not high enough to ignite the incoming coal.

TABLE 10. SHOWING VALUES OF 1¼-INCH COAL SCREENINGS AS AFFECTED BY AVERAGE DIAMETER OF THE PIECES AND VARIATION IN ASH CONTENT.

Average Diameter of Coal in Inches.	Per Cent. of Ash in Dry Coal.													
	4	6	8	10	12	14	16	18	20	22	24	26	27	30
	Values of 1¼-inch Coal Screenings.													
0.06	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.10	0.24	0.24	0.23	0.23	0.23	0.22	0.21	0.21	0.20	0.20	0.18	0.17	0.16	0.15
0.15	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.41	0.39	0.38	0.35	0.34	0.31
0.20	0.75	0.73	0.72	0.71	0.69	0.67	0.65	0.63	0.61	0.59	0.53	0.50	0.45	0.41
0.25	0.91	0.89	0.88	0.87	0.85	0.82	0.80	0.77	0.75	0.72	0.69	0.65	0.61	0.55
0.30	0.96	0.94	0.92	0.91	0.89	0.86	0.84	0.82	0.78	0.75	0.72	0.68	0.64	0.58
0.35	0.80	0.79	0.77	0.76	0.74	0.72	0.70	0.68	0.66	0.63	0.61	0.57	0.54	0.49
0.40	0.68	0.67	0.65	0.64	0.63	0.61	0.60	0.57	0.55	0.53	0.51	0.48	0.46	0.41
0.45	0.65	0.64	0.62	0.61	0.60	0.58	0.57	0.55	0.53	0.51	0.49	0.46	0.44	0.40
0.50	0.67	0.66	0.64	0.63	0.62	0.60	0.59	0.57	0.55	0.52	0.50	0.48	0.45	0.41
0.55	0.71	0.69	0.68	0.67	0.66	0.63	0.62	0.60	0.57	0.55	0.53	0.50	0.47	0.43
0.60	0.75	0.74	0.73	0.72	0.70	0.68	0.66	0.64	0.62	0.59	0.57	0.54	0.51	0.46
0.65	0.81	0.80	0.78	0.77	0.76	0.73	0.72	0.69	0.67	0.64	0.62	0.58	0.55	0.50
0.70	0.89	0.87	0.86	0.85	0.83	0.80	0.78	0.75	0.73	0.70	0.67	0.63	0.60	0.54
0.75	0.96	0.94	0.92	0.91	0.89	0.86	0.84	0.81	0.78	0.75	0.72	0.68	0.64	0.58

Coal of Too Large Size with Stokers

A large coal company had a case of serious trouble with an important customer. The question was one of quality of screenings. Two mines were involved, which may be designated as *A* and *B*. Mine *A* was located upon what may be called the Central Railway, while *B* was upon this railway and also connected with what may be designated as the Western Railway, both of which roads terminated in the city where the coal was used. It appears that shipment had been from mine *A*, but owing to lack of orders for lump coal on the Central Railway, this screening order was transferred to mine *B*, because there were lump-coal orders which could be shipped over the rails of what is called the Western Line. When this transfer was made, the customer immediately complained, claiming that the coal from mine *B* was of an inferior character and not at all suited to the purpose, which was steam production in boilers served with a certain type of stoker. These two mines were located about ten miles apart and operated in the same coal seam. As far as chemical analysis and physical conditions are concerned, the seam at both places is exactly the same, and from this standpoint it would be difficult to find, in the quality of the coal itself, the reason for the trouble. But the screenings from mine *A* had been delivered in steel cars, bearing the imprint of the Central Railway, while the coal shipped from mine *B* came in wooden cars, bearing the imprint of the Western Railway. This in itself was an apparent evidence to the purchaser that the coal was different, which belief was confirmed when it was placed in the stoker and failed to produce as good a fire as had the former screenings. The facts, however, were that mine *A* was equipped with a perforated screen having 1¼-inch round openings, while mine *B* had a bar screen, set somewhat further apart; the size of the openings, instead of being limited to the width, were the full length of the screen. The result was that the screenings produced by it were of a considerably larger size than those produced at mine *A*, because larger pieces passed through the bar screen. In fact, from the standpoint of the coal business, it was a superior fuel, because the size was larger, also from an analytical standpoint, because owing to the presence of a greater percentage of large pieces, the ash content was lower.

It was in fact this superiority that caused the trouble. The coal was too large to form a sufficiently compact fuel bed on the stoker, with the result that an excessive quantity of air flowed through it, producing unsatisfactory combustion. The customer did not understand this feature, however, and attributed the trouble to some inherent quality of the coal itself, and believed that it was a fuel of an entirely different nature, something on the order of an anthracite rather than bituminous coal.

At this stage of the matter the customer was satisfied by screenings shipped from another mine, which operated in an entirely different coal seam, although producing fuel through a 1¼-inch shaker screen with round perforations. Thus, it appears an actual change in the quality of the coal itself, although slight, when accompanied by suitability in size, gave satisfaction.

Exceptional Example of Benefit from High Ash Content

A large coal user, in an experimental way, invaded a new field for its fuel supply and a number of tests under boilers were made. The screenings from a certain mine gave an unusually high efficiency compared with those obtained from other points in the same general locality. This fuel, however, was extremely high in ash, but it was felt, at the time, that the coal was especially suited to requirements, although the high ash content was considered an objection and an investigation was made to ascertain if "similar" coal containing a reasonable ash content could be found. The investigation showed that, while the fuel in question contained a very large amount of ash, it was not of a seriously fusible character, therefore did not make trouble by clinkering, and that the amount of ash was sufficient to close the opening at the back end of the furnace between the bridgewall and end of the stoker grates, thereby excluding a very large excess of air which had found entrance when other coal of much lower ash content had been burned. An investigation at the mine showed that the roof was of such nature that a large amount of dirt became, at times, mixed with the screenings, but that as far as the coal itself was concerned, it was not different from adjacent mines, but which, however, had a much stronger roof and for this reason produced screenings which had much less dirt mixed with them. This is an illustration of an exceptional instance where high ash produced a desirable result.

Bad Stoker Action

A steam-boiler plant served by a particularly faulty mechanical stoker, was the cause of much trouble and indifferent service. On one particular occasion, however, performance was unusually satisfactory and the manager decided that it was due to his having some special coal which was superior to that usually burned. He thereupon called up the coal company and asked where the coal was produced. He was given the town and the mine from which it was shipped. He therefore decided that it would be desirable to obtain coal in the future from this mine. The dealer, however, was unable to regularly supply it, but shipped from an adjoining mine only a few miles distant, operating in the same seam and whose source of coal was exactly the same as the other mine. The performance of the plant when it was burned, however, was not satisfactory. This led the manager to call up the coal dealer and complain of the fuel. He was told that it was from the same locality and that it should in every way give the same result as that from the mine which he considered satisfactory. But in an effort to please the customer, special pains were taken to obtain additional coal from the desired mine and a report as to its performance asked for. The statement of the operator of the plant was that it was no better than the previous shipments. He was then told that it was fuel from the mine which he wanted and which he had stated had given satisfaction before. Notwithstanding the explanation, the manager could not realize that the fuel was from the same place as that which he had considered to be suited to his requirements and felt that if the coal dealer would deliver him "the right kind of coal" he would have no trouble.

Example of Confusing Report from Employees

Coal dealer No. 1 supplied a certain size of washed coal by wagon to a customer. When the time of expiration of the contract approached, coal dealer No. 2, who was an important patron of the customer, solicited the business for the coming year for his company, with the result that the contract was awarded to him. Dealer No. 2 purchased coal, which was of the same size, from the same producer who had furnished it to dealer No. 1. He sent his teams to the same team track, loaded it out of cars of the same railway, or, in other words, furnished exactly the same product that dealer No. 1 had supplied and it would be reasonable to expect that the results and service would be identical, but the report received from the boiler room was that the fuel supplied by the new dealer was decidedly inferior in quality to that which had been received from the previous dealer, that a much larger quantity was required to do the same work and that the cost of furnace repairs had been increased owing to its use. The purchaser, of course, who could understand none of these things himself but who must depend upon the statement of others, laid the case before dealer No. 2 and explained to him that while he was very anxious to reciprocate in a business way, he expected to receive equally good fuel as that which had been delivered under the previous contract. Of course, fuel furnished by the two dealers was of precisely the same grade, quality and prepared by the same washer, but how could the customer be expected to believe it in the face of statements of his own employees?

It is not the intention in the foregoing to intimate that the coal dealer or producer always furnishes satisfactory fuel, or that he delivers what he should, but it is the purpose to show to what extent and in what way it may be possible for him to fail to meet the consumer's demands.

B.t.u. in Coal

By J. M. Leunam

Manufacturers have for many years known that the value of coal depends upon the heat units in a pound, or, as we say, British thermal units per pound, which is usually abbreviated to B.t.u. They have been much handicapped in not having a ready method of determining such units, being unwilling to employ chemists for this purpose, or to go to the expense of a coal calorimeter and its operation.

A coal agent suggested to me a happy rule for determining this. It is such a valuable rule that all readers of Power should be informed of it. It involves no intricate analytics, trigonometry or calculus, but simply the multiplication and division of numbers. The rule is as follows:

Divide the pounds of coal in a car by the railroad number of the car, and multiply the quotient by the price per ton. The final result is the heat units or B.t.u. per pound.

In this connection, it may be interesting to know that a green salesman for coal approached an engineer of a large company recently, with a view of securing his year's business. The engineer asked him how much sulphur the coal contained. The salesman was ready with his answer and said, "As low as 1 per cent." The engineer next asked him how much ash was in the coal. Again he was ready with his reply and stated that it had 5 or 6 per cent. The engineer next asked him how much fixed carbon was in the coal. That was a new term to the salesman, but he was going to carry his bluff and said, "From 15 to 20 per cent." The engineer next asked him how many B.t.u. were in the coal. The salesman was again ready with his reply and said, "Do you know we have tried time after time to find those pesky B.t.u. but we have never succeeded in locating one in our coal."

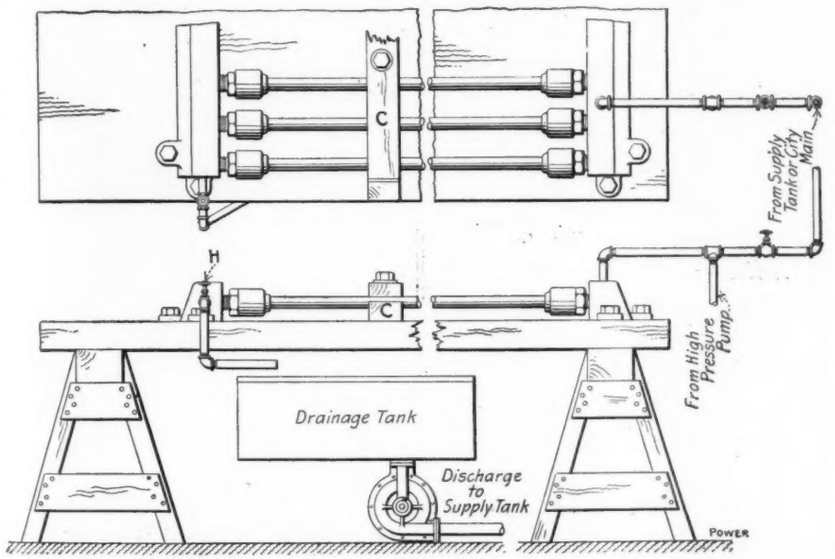
Reëxpanding Condenser Tubes

By Frank S. Bunker

Description of an apparatus designed to reëxpand old surface-condenser tubes and fit them for further use. Rigs for sawing the tubes and for hydrostatic testing.

In condenser tubes the most common defect is to have the ends crushed in by the packing. This not only causes a reduction in area of the tube, but also necessitates a large size of packing, which, as a rule, tends still further to crush the tube.

A rig which is used on the Pacific coast to roll the interior of the tube back to its original size is shown in Fig. 4. The rig was made by placing two small speed lathes tail to tail, with the headstocks in line. One lathe was bolted securely to the floor, and the other secured in slides which allowed the lathe to be moved to admit of longer or shorter tubes being handled.



FIGS. 1 AND 2. TOP AND SIDE VIEWS OF APPARATUS FOR TESTING CONDENSER TUBES

Block *A*, Fig. 4, is mounted on the shears of the lathe and securely held there on a proper fitting, in a central position. This block is of tool steel, hardened, and is hinged so that it will open and admit the tubes. The block is provided with a half-round groove in both top and bottom halves and, when the block is closed and locked, these grooves form a perfectly round hole the exact outside diameter of the tube when new.

A boilermaker's tube roller is used, only it is in miniature and made to roll the tubes to the proper inside diameter. With two boys, one at each lathe, the operation is simple.

CUTTING OFF

If the tubes are to be used in any but the original condenser from which they were removed, the length of tube required may be less, and the tubes must be shortened.

The rig shown in Fig. 5 is an excellent one for cutting them to the proper length. It is made with a column *A*, which is bolted to the table of a milling machine. The top of this column is cut out to receive the ends of the steel leaf spring on the end of which is a hinged clamp which is held open by a small steel-wire spring.

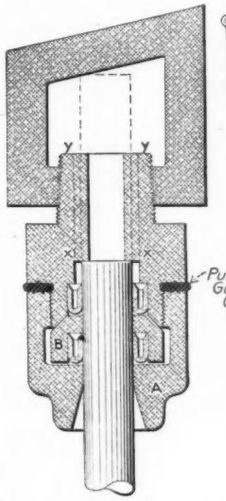


FIG. 3. CONNECTION TO MANIFOLD

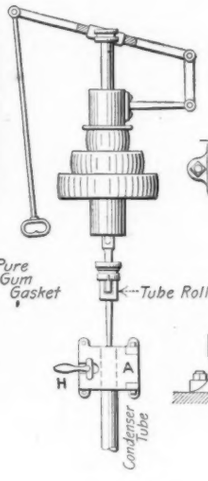


FIG. 4. EXPANDING TUBE IN LATHE

The tubes are backed against some conveniently arranged stop, and the end to be cut is rolled into the bottom half of the clamp. With a downward motion of the handle, the top of the clamp comes into contact with the tube, securely holding it and bringing it into contact with the saw. The burs are removed with a cutter bar and small cutter mounted in an air drill which is held in a vise, the tubes being pushed against the cutter.

TESTING

To make sure that the tubes are perfect the testing rig shown in Figs. 1, 2 and 3 is used. In the economical testing of small parts, such as tubes, etc., speed is the main object and it was with this in view that the rig was designed. It consists of two hollow manifolds of bronze, suitably designed to stand 1000 pounds per square inch hydrostatic pressure. One of the manifolds is mounted at the end of any suitable base, such as a long piece of boiler plate. The other manifold is mounted so as to be adjustable along the length of the base and thus permit the testing of various lengths. It must, however, be bolted securely to the base.

Fig. 3 shows the fitting which holds the tubes and forms a water-tight joint. This is made possible by the hydraulic cup leathers. The front end, or mouth of the fitting, is made bell shape to facilitate the adjusting of the tubes. One fitting is made like the sketch and the one which is to take the opposite end of the same tube is bored through on the dotted lines *x y*, *x y*.

To place a tube in the rig, simply shove it in through the bell mouth as far as it will go (see dotted lines showing extension of tube, Fig. 3). The other end of the tube should now be just clear of

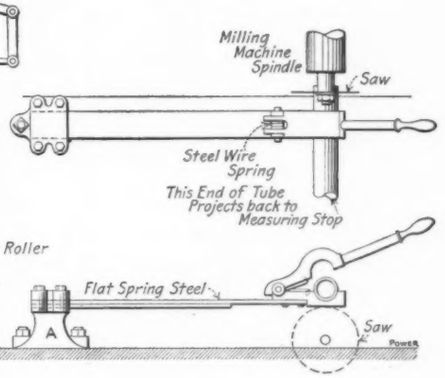


FIG. 5. RIG FOR SAWING OFF TUBES

the bell-mouthed fitting in the manifold. Pull back and shove the tube into this fitting until it strikes the shoulder *x x*, and when tubes are in all of the fittings proceed with the test.

Owing to the tendency of the tubes to buckle, it is necessary to put on a restraining clamp, as shown at *C*, Figs. 1 and 2. This consists of a piece of timber grooved to let the tubes rest in it, and with another timber swiveling on a central bolt to swing over and clamp them down. For long tubes, two or more clamps of this nature may be necessary.

There is no restriction as to the number of bell-mouthed fittings to put in the manifold, as the more fittings the greater economy. By making the parts *A B*, Fig. 3, in one size for ¾-inch tubes, and another set for ⅝-inch tubes, the same manifolds will serve for the two sizes. When the apparatus is in use, be sure to leave valve *H*, Fig. 2, open until the tubes and manifolds are filled with water to the exclusion of all air; then close it.

An outfit of this kind is in use on the Pacific coast and is doing excellent work, saving a great deal of money. I hope someone else may find use for it, as it "delivers the goods."

The Patitz Steam Turbine

The energy required to get a weight *W* into motion at a velocity of *V* feet per second is $\frac{W V^2}{2 g}$.

Taking *g* at 32.16 the energy in a pound weight would be approximately

$$E = 0.015\ V^2$$

The energy is thus seen to vary directly as the square of the velocity. A body one pound in weight having a velocity of 1000 feet per second has stored in it

$$0.015 \times 1000 \times 1000 = 15{,}000$$
foot-pounds

of energy; but if it has a velocity of 2000 feet per second it has

$$0.015 \times 2000 \times 2000 = 60{,}000$$
foot-pounds

To increase the velocity of a body 1000 feet per second starting from rest, then, takes some 15,000 foot-pounds; but to increase its velocity another 1000 feet starting from 1000 feet per second takes some 45,000 foot-pounds.

A turbine blade running at a certain speed will reduce the velocity of the jet passing through it a certain amount. Suppose this reduction to be 1000 feet per second. Then, if the jet enters the wheel at 2000 feet per second and leaves at 1000, the wheel will take out 45,000 foot-pounds of energy for each pound of steam passing, but if the reduction be from 1000 feet per second to rest, the same wheel at the same speed would take out only 15,000 foot-pounds.

If the velocity of a body is doubled it will have four times the energy stored in it. If the velocity of a body is halved three quarters of its energy will be taken out. The inventor of this turbine, instead of getting up a low velocity and abstracting practically all of it in each stage gets up a high initial velocity, abstracts about one half of it, restores the initial high velocity by further expansion for the next stage, and gets out three times as much energy per stage as a turbine working on the lower half of the velocity range.

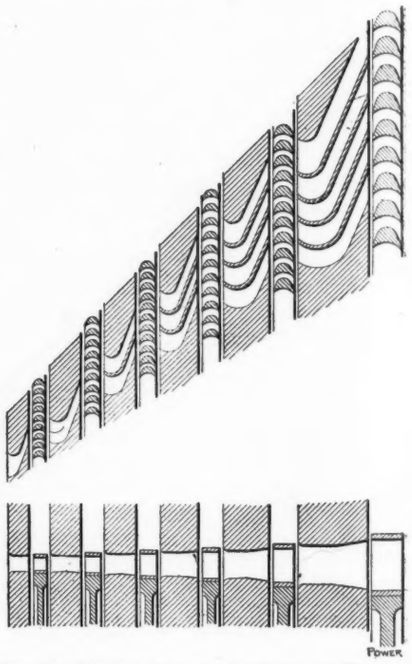


FIG. 2. DIAGRAMMATIC SKETCH OF PATITZ TURBINE

Based upon this fact, J. F. M. Patitz, of the Allis-Chalmers Company, has taken out a patent for a steam turbine in which the steam enters the first wheel at a comparatively high velocity. This velocity is only about one-half abstracted, however, by the runner, and the residual velocity is increased again to the maximum by further expansion before the steam acts upon the second wheel.

Fig. 1 represents diagrammatically an abstract case, the ordinates being velocities and the abscissas energy converted. Suppose the total energy derivable from a pound of steam flowing from the initial to the condenser pressure to be 240,000 foot-pounds, represented by the length of the line *O A*. Suppose that in a turbine of the multiple pressure-stage, single velocity-stage type, like the Rateau,

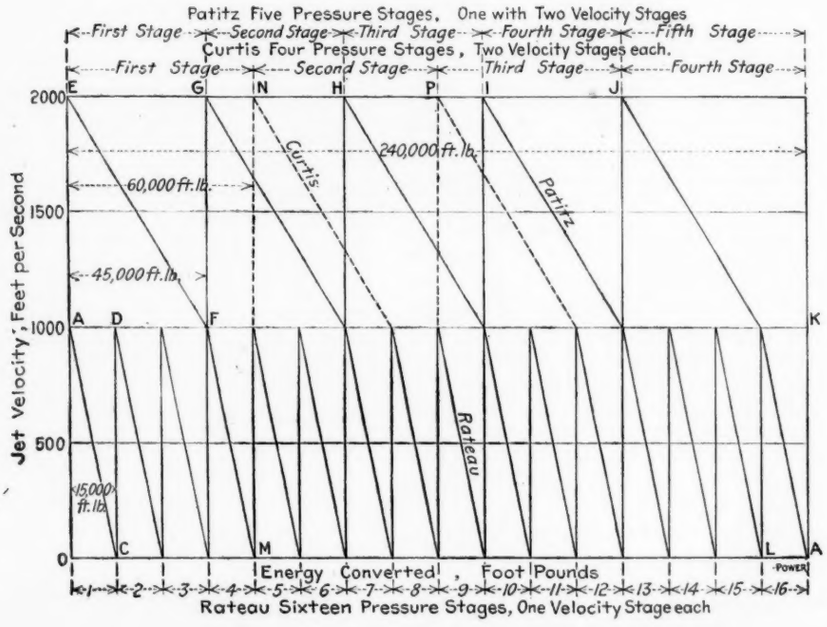


FIG. 1. ENERGY-VELOCITY DIAGRAMS FOR THREE TYPES OF TURBINES

the steam is expanded in the first stage sufficiently to give it a velocity of 1000 feet per second, represented by the line *O A*. Then a turbine wheel running at 500 feet per second (this takes no account of angle of entry, friction, etc.), would bring it to rest again, and convert into work the 15,000 foot-pounds of energy required to get up its velocity of 1000 feet per second. Its velocity would then be raised to 1000 feet per second again by expansion in the second set of nozzles, as represented by the line *C D*, and the process repeated until the 240,000 foot-pounds available had been all absorbed. This would, as the diagram shows, require 16 stages, absorbing 15,000 foot-pounds each, as

$$16 \times 15{,}000 = 240{,}000$$

If, however, the steam be sufficiently expanded in the first set of nozzles to give it a velocity of 2000 feet per second, represented by the line *O E*, a turbine running at 500 feet per second would reduce its velocity to 1000 feet per second and convert 45,000 (represented by the distance *A F*) of the 60,000 foot-pounds required to get up its initial velocity. If now its velocity is restored to 2000 feet by further expansion, as represented by *F G*, and the process is repeated it will be seen by the triangles whose apexes are at *E, G, H, I* and *J* that the process could be completed in five stages. Not completed exactly, for the steam would leave the last wheel with a velocity of 1000 feet, as shown at *K*, and it would be necessary to put in an additional low-velocity stage to reduce the velocity from *K* to *A* and rescue the last increment of energy *L A;* or to double

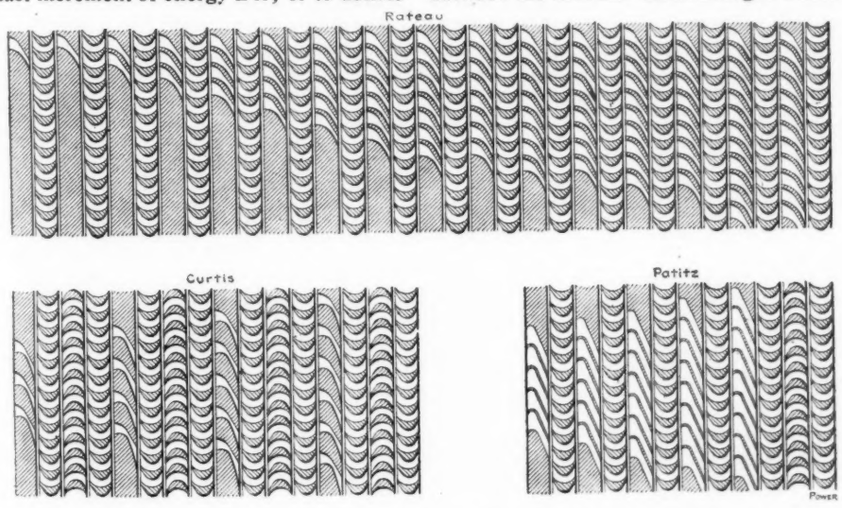


FIG. 3. A COMPARISON OF THE THREE TYPES OF TURBINE

blade the last wheel, as in the Curtis system, in which case the second blade upon the same wheel would take the steam at 1000 feet velocity, reversed in direction by a stationary blade between the two moving ones, and bring it to rest.

If the whole turbine were made in this way it would require but four stages, but with three times the amount of blading in each. In addition to the single blade of the Patitz wheel there would be the stationary reversing blade and the secondary running blade in each stage. A comparison of the three systems in this respect is shown in Fig. 3.

The course upon the diagram, Fig. 1, would be: generation of velocity to 2000 feet per second, *O E;* reduction of velocity to 1000 feet per second, *E F;* with the first running blade, reversal of direction by the stationary blade and reduction from 1000 feet per second to rest, *F M*, the absorption for the whole stage being 60,000 foot-pounds, *O M*. Expansion between the first and second stages would restore the velocity to 2000 feet per second, *M N;* and the process would be repeated, giving the four diagrams similar to *O E F M*, the apexes of which are at *E, N, P* and *J*.

This is, of course, simply an abstract discussion, the principal modification of which to make it apply to a comparison of the actual machines would result from the fact that some residual velocity is inevitable at all the wheels, which rather emphasizes the advantage of the new type. A disadvantage is that all the steam is used at high velocity, involving greater friction upon each blade, but there is a smaller number of blades subject to such friction.

The arrangement of the blades wherein the direction of flow is reversed and the residual velocity preserved and increased by further expansion is shown in Fig. 2, and a section of the turbine in Fig. 4, both reproduced from the patent drawings.

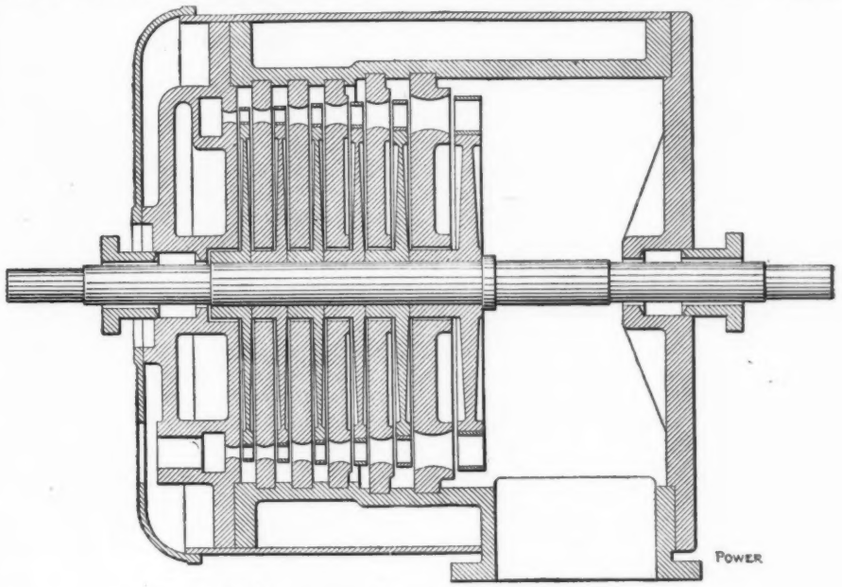


FIG. 4. LONGITUDINAL SECTION THROUGH TURBINE

Why Smithy Didn't Get a Job

An erecting engineer was recently called upon to go to a steam plant in a city not many miles from Brooklyn, N. Y. Arriving at the plant he found that the running engineer had substituted a new throttle valve in place of the old one, but could not start the engine—why, he did not know.

The erecting engineer cast his eagle eye over the engine, and at once located the trouble, or rather troubles. The steam chest was cracked. The engine frame was broken and the crank rod was badly bent. Later he learned that the engine had received a dose of water the day before, and that the engineer, in his ignorance, blamed the throttle valve, when the engine would not start, not knowing that the engine had sustained serious injury.

Some time later, as the erecting engineer was putting the finishing touches on a new installation, a voice addressed him saying, "What is the chance of a job, governor?" When the erecting man turned to answer, he beheld the engineer who had the throttle-valve trouble. Well, he did not get a job.

Uncle Pegleg on Force of Gravity

In which the old man tells, in his simple way, all about gravity and incidentally why Jim and the salt bag did not balance.

Fogchurn Hollow, Tenn., March 15, 1911.
Dear Uncle Pegleg:

I've bin readin' some of your talks with the kid in POWER (which hits the trail into this here lumber-chuck about as regular as the mail man) about ropes and pulleys and things. I want to ask you some questions about things in that line I can't understand.

'Bout three weeks ago I made a trip with anuther feller down the crick to town, to see the sights. Most of what we saw I don't remember very well, but early in the day we went around to the artifishul-ice plant to see how they made ice by machin'ry. and there we saw a sight I shan't forget so long's I live—though's I kum so pretty near dyin' o' laffin' right there I wuzn't so far from forgittin' that too.

They got a sizable engineer down to that plant, named Jim Taintor. My chum's father knowed him, and thet's how we kum to dare go round there and ask questions. Jim's got more fat to him th'n he has git-up-n-git. He don't ketch himself doin' 'n hour's labor thout he spends about half a day figgerin' out which is the easiest way to do it. Thet's how he come to do the vodeville act that near bust us up.

Ye see, they use a lot o' salt to thet plant, to make the ice—though Jim showed us as how they didn't use the salt to make the ice cold, 's they do in makin' ice cream, but only to make brine what wouldn't freeze. (Funny, I thought, to spend all thet money to make somp'n what wouldn't freeze, when the whole fact'ry was set up to make things freeze.) Howsmdever, they do use a lot o' salt, and it comes in big wagonloads o' sacks, and its Jim's job to get the sacks up into the storehouse loft above the "can room," as they call it.

Well, so Jim told us after he got cooled off some, them bags o' salt weigh about 180 pounds apiece. The only helper Jim's got, besides his fireman, who can't leave his fires, is a boy not big enough to do much pullin' on the rope. Besides, Jim needed him up in the loft, to untie the bags when they got up there. So he had to pull 'm up there himself, 'n they air heavy enough to most pull Jim off'n the ground—he weighs only about 200—at ev'ry heave.

So Jim got his thinker to work and figgered out 's how his legs were lots stronger 'n his arms—just 's sailors, he said, knows enough not to pull ropes down with their arms, but to jump up on it with their leg strength 'n then let their weight swing the rope down. So he'd first tie the rope to a sack o' salt on the ground, 'n then climb upstairs to the loft, ketch holt o' the rope out o' the door, 'n swing himself out on the rope. All he had to do was to hold on tight, 'n down he'd kum, just as easy, while the sack went up past him 'n stopped opp'sit the door when Jim stopped on the ground. Then the boy d' pull the sack in the door, untie the rop 'n Jim 'd be ready for another trip upstairs.

This went bully. But one day the salt man got a carload o' salt from a new place, 'n without sayin' anythin' to Jim about it he sent round a wagonload o' salt in sacks 'at weighed only about 120 pounds to the sack. Jim didn't notice no difference, 'n tied the first one on and clumb upstairs an' swung hisself out on the rope, expectin' ev'rything to work just 's it allus had. But it didn't work that way. Stead o' slidin' down easy to the ground he went away like a shot. The sack got such a yank thet it bumped Jim pretty hard on its way up, 'n bout time he wuz gettin' straight in his mind what had happened to him when the sack hit him, he found the ground had kum up 'n hit him hard from below—a good deal harder 'n ennybody 'd ever hit Jim that way sence he was a small boy; for it had all happened so quick Jim hadn't had time to get his feet down into shape fur landin', 'n he came down sittin' down.

But he didn't have much time for bein' dazed, cause when he landed he hit so hard, what with the whack the sack had given him on the way down, thet he let go his holt on the rope. Well, o' course, then the sack o' salt, which was up opposite the loft door, started back home agin; 'n as the boy had already caught holt of it, he a'most kum too. But he let go in time.

The sack didn't come down very fast, for it couldn't move along thout whippin' the rope, coil after coil, out from under Jim, 's he sat there wonderin' whether he'd been a big enuff fool to deserve treatment like that. The sack pulled powerful hard 'n jerky, 'n Jim couldn't help wonderin', he told me afterward, what sort of a horizontal buzz-saw it wuz he'd set down on, ennyhow.

Pretty soon he quit wonderin' 'n commenced to talk. I spose he'd made up his mind as to the buzz-saw, 'n was speakin' it freelike. Ennyhow, the langwidge was most enuff to make that sack o' salt ashamed o' intrudin' on his sassiety 'n turn round 'n go back to the loft agin. But it didn't do no sech thing. It kum right along down. 'N just about the time Jim had made up his mind that not even strong langwidge could appeal to thet buzz-saw, 'n he'd better stand up, the sack o' salt kum along 'n countermanded the order. It knocked Jim so flat there wuzn't no room left for langwidge at all.

He lay there so long I really thought he wuz hurt, though chum 'n me wuz so bad off for laffin' we couldn't do ennythin' to help. But he kum to bout 's soon ez we did—'n then we *had* to quit laffin' 'n ask him if he wuz hurt, 'n where.

It wuzn't until I got back up the crick on the job agin thet I've hed time to think about this thing. I haven't been able to figger out just how this thing happened, 'n why it wuz he went so much faster 'n usual. No, I don't mean thet. I can see *why* he went faster, but I can't figger out how ennyone wuz to know *how much* faster he wuz to go, under sech tryin' circumstances 's a 120-pound sack o' salt. Please help me, Uncle Pegleg.

Your lovin' nevvy,
DAVE.

The problem which is puzzling Dave is an important one, for it concerns all cases where force sets matter into motion.

Our most familiar instance of such a phenomenon is that of simple falling bodies, where there is no rope and counterweight attached to complicate the problem. We are accumstomed to say: "Oh, a body falls 16 feet the first second, 32 feet the next, and so on." But the schools do not commonly teach the broad significance of this fact.

We who live on the surface of the earth, where all bodies, except for air resistance, have this same rate of fall, naturally take this particular rate for granted, as an inherent property of matter. But, those who live elsewhere at times—and every mind which studies natural science must often wander above and below the surface of this earth—know that this is not so.

Every solid body presents to our senses at least two qualities. One is its *mass*. The other is its *weight*.

The mass of a body is the quantity of matter within it. This naturally is the same, wherever you may carry it. If Dave, for instance, should heave a chunk of coal at his chum, it would strike just as hard a blow wherever the act was performed, at sea level, on mountain top, on the surface of the moon or of Mars etc.

The *weight* of a body, on the other hand, is not an attribute of that body, but of its relationship with other, usually larger, bodies, such as the earth, moon, Mars, etc. Consequently it varies whenever you change either the other body or the relationship with it. This

same chunk of coal, for instance, would weigh quite differently at the earth's surface accordingly as it were at the sea level, up in a balloon, down in a mine, at the North Pole, at the equator, etc. It would also weigh quite differently at the surface of the moon, Mars, etc., from what it does anywhere on earth.

Now *motion* is merely the result of the effect of this varying force *weight*, acting upon this constant *mass*. It is only a coincidence that at all the places inhabited by man the force of weight is so nearly constant that we say that the rate of fall is constant. Horizontally we may have any force acting on a given mass and any resultant rate of motion; and, in mechanical engineering, these laws of horizontal motion are all-important.

It was Sir Isaac Newton who first gave us the law of motion, or of acceleration, to speak exactly. He said that (a) the acceleration, or the gain in velocity each second, is proportional to the force and (b) told us what that proportion is.

We know, for instance, that when we drop a piece of iron which weighs one pound, the velocity at the end of the first second is about 32.16 feet per second. Therefore, this is called an acceleration of 32.16 feet per second.

According to Newton, this fact represents the broad law that

$$Force\ (=\ weight)\ =\ 32.16\ \times\ mass$$

From this we get

$$Mass = \frac{weight}{32.16} = \frac{W}{g}$$

wherein g is the acceleration of gravity. Or, for other rates of acceleration,

$$Acceleration = \frac{force}{mass} = \frac{force}{\frac{W}{g}} = g\,\frac{force}{weight}$$

In other words, the acceleration is proportional to 32.16, as the force is to the weight of the body subjected to it.

These facts are very hard to study on the earth's surface, because all vertical motions are tied down to the particular vertical force (gravity) which we cannot get rid of here, and all horizontal motions are afflicted with heavy friction due to the same. Newton studied the problem in the heavens, astronomically, because there we get rid of these earthly obstacles. But we ordinary mortals cannot do this.

To help this situation out a famous scientist, Atwood, built a machine modeled quite after Jim's salt-loft pulley and whip. By using *two* weights instead of one, attached to the two ends of a cord passing over a pulley above, and by making the pulley very carefully to be as frictionless as possible, vertical motions could be used and yet the effective weight of the mass being studied could be varied.

That is to say, in this machine the mass being set into motion is the *sum* of the two bodies. The force or weight which is promoting their motion is their *difference*. So, by making the two bodies fairly nearly the same weight, their sum becomes very large in comparison with their difference. Consequently, the motion will be very much slower than that of freely falling bodies and can be studied much more conveniently.

THE SACK OF SALT KNOCKED JIM SO FLAT THERE WUZN'T NO ROOM LEFT FOR LANGWIDGE AT ALL

If we take Jim and his salt bag as an instance of such a machine, and disregard the friction of the pulley and rope, it appears that the sum of Jim's weight and that of the salt is, in the first case, 380 pounds and in the second 320 pounds. Consequently, the mass to be moved is about 11.8 and 10 units respectively.

The motive force, on the other hand, would be the difference of the two weights, or 20 and 80 pounds, respectively. Consequently, the rate of acceleration would be, in the first place,

$$\frac{20}{11.8} = 1.69\ feet\ per\ second\ per\ second$$

and in the second case

$$\frac{80}{10} = 8\ feet\ per\ second\ per\ second$$

In the first case the time, speed and distance of fall would range as follows:

Time, seconds	1	2	3	4
Speed, in feet per second	1.69	3.38	5.07	6.76
Distance that second, feet	0.84	2.53	4.23	5.91
Total distance, feet	0.84	3.37	7.50	13.41

Therefore, Jim would reach the ground in about four seconds and would be moving at the rate of 6¾ feet per second, or about 4½ miles per hour.

In the second case the corresponding figures would be:

Time, seconds	1	2	3	4
Speed, feet per second	8	16	24	32
Distance that second, feet	4	12	20	28
Total distance, feet	4	16	36	64

Consequently, Jim would reach the ground in less than two seconds and would be moving at a rate approaching eleven miles an hour.

Atwood's machine is not relied upon for refined determinations of the ratio of acceleration to force. We rely upon finely constructed pendulums for that. But it is the best known illustration before students of the generality of the law connecting force, mass and acceleration.

UNCLE PEGLEG.

Engines in British Rolling Mills

By Thomas B. Mackenzie

Abstract from a paper recently delivered at a meeting of the Institution of Engineers and Shipbuilders in Scotland. The relative merits of simple and compound engines for rolling-mill work are considered and also the application of low-pressure turbines.

Steam engines in use in the early days of the malleable-iron trade were mostly of the simple noncondensing type working with a late cutoff. As the puddling and reheating furnaces were able to supply enough steam for them, and as there was then no other known method of using the surplus heat, there was no inducement to install more economical types. With the advent of steel, however, this was changed; more power was required for rolling and less waste heat from the furnace was available for the generation of steam. Then when it became necessary to install new engines some attempts were made to improve their steam economy. The simplest of these was the introduction of feed-water heaters and by this means a saving of from 10 to 12 per cent. was obtained.

In the case of mills the rolls of which run continuously in one direction, compound-condensing engines of the most modern type with automatic expansion gear have been, and still are being, used with excellent results. In the case of reversing rolls the case is different. Early attempts at compounding such engines in England ended in failure and prejudiced those in charge against them; and it is only since they have been introduced successfully on the Continent that they are again beginning to be taken up by English steel makers.

The conditions which a reversing rolling-mill engine must fulfil are briefly these: It must be simple and free from all unnecessary complications, in order that it may be able to work day and night with the minimum risk of breakdown; it must be able to start with the cranks in any position, and with the load on; and it must be easily handled; the handles requiring to be continuously used should never be more than two, one for the steam and one for the reversing gear. The first of these conditions is met by making all the motions as direct-acting as possible and giving all parts ample strength. The second condition means that with two-crank engines the cutoff cannot be earlier than 75 per cent., and with the three-crank engines 55 per cent. of the stroke. The third condition almost prohibits the use of expansion gears, and leaves the control of the engine to be effected by throttling the steam supply, which operation is as follows: The engine is turning slowly round in the proper direction when a hot ingot is brought forward and caused to enter between the rolls; the driver at this instant opens the throttle and the ingot is pulled through, the throttle being closed just as the steel is about to leave the rolls. There is still steam in the connecting pipes and valve chests, which, together with the kinetic energy stored in the rotating parts, causes the engine to race until the reversing gear has been brought into use, when the engine begins to rotate in the opposite direction. The steel again enters the rolls and the operation is repeated until it has been rolled down to the required dimensions.

The early compound engines made in England were constructed in the way usual in land and marine practice, with a throttle on the high-pressure cylinders only; consequently, the racing was very much accentuated. In addition to the steam in the high-pressure pipes and valve chests, there was the steam in the connecting pipes, intermediate receiver and low-pressure valve chests. Furthermore, when the engine had been reversed the receiver pressure had fallen to that in the exhaust pipes of the low-pressure cylinders, and only the high-pressure cylinders were available for starting the mill. The drivers had, therefore, to use their own expression, "to take a race at it," that is, the engine was allowed to get up to speed before the piece was entered, causing severe shocks and often leading to breakdowns; hence the compound engine was condemned as unsuitable for rolling-mill purposes.

As is commonly the case, the cure is almost ludicrous in its simplicity, consisting as it does in merely placing a valve between the intermediate receiver and the low-pressure valve chests, connected to, and acting along with, the high-pressure throttle valve. Therefore, when the driver closes the throttle valves, he bottles up the steam in the receiver, and the steam in high-pressure pipes and valve chests, together with the kinetic energy stored in the rotating parts, compresses this steam and raises the receiver pressure, at the same time bringing the engine quickly to rest. On reversal the receiver supplies the low-pressure cylinders, so that all are available for starting under load, and the engine starts easily.

The question: "How much steam does a reversing rolling-mill engine use per horsepower-hour?" is perplexing, and one to which it is difficult to obtain a direct answer. Last year a paper was read at the London meeting of the Iron and Steel Institute by Messrs. Sehmer and Drawe on "Economy and Design of Modern Reversing Rolling Mill Engines," in which it was stated that on a forty-five hours' test of a compound rolling-mill engine the average steam consumption was 350.77 pounds per ton of material rolled to 9.222 times its original length. This is equivalent to about 22 pounds per horsepower-hour. The steam pressure was 103 pounds gage, and the absolute back pressure in the low-pressure cylinders 3.25 pounds per square inch. It was also stated that formerly, with a noncondensing engine, under the same conditions, the steam consumption was 880 to 1100 pounds. In the case of the compound engines the steam consumption named is said to have included that required for the condenser pumps and auxiliaries. There can be no question as to this being an exceptionally good performance, and one which could not be maintained under ordinary working conditions. For everyday practice 24.2 pounds per horsepower-hour will be nearer the figure.

Until within the last few years the only use to which the heat in the exhaust steam from noncondensing engines could be applied was for heating feed water, etc. Since the advent of the steam turbine, however, it has become possible to collect this steam in a closed system of pipes and use it in exhaust-steam turbines. Such an installation, when used with intermittent running engines, consists of three essential parts: first, a thermal storage tank, called by Professor Rateau the heat accumulator; second, the turbine proper, and, third, the condenser and its pumps. The pressure in the thermal storage tank supplying these turbines is usually 17 to 17½ pounds per square inch absolute. It is dangerous to let the pressure fall to that of the atmosphere, and fatal to let it get below that point. To prevent such an occurrence it is customary either to fit a reducing valve which will allow live steam to pass at the lowest permissible pressure in the storage tank, or, as in more recent practice, to use a mixed-pressure turbine. There can be no question as to the latter being by far the better method, as the live steam can then be used with maximum efficiency.

In considering the adoption of an exhaust turbine, it must be kept in mind that the result of its introduction will, by raising the back pressure, increase the steam consumption of the engines exhausting into the thermal storage tanks.

In the case of the noncondensing engine cited, it would increase the steam consumption about 20 per cent. The increase of back pressure will not be less than three pounds per square inch. The loss by condensation, leakage, etc., between the reciprocating engines and the turbines will generally be about 15 per cent. For every 100 pounds of steam which a noncondensing engine uses when exhausting freely into the air, it will, when connected to thermal storage tanks, use 120 pounds. Of this 102 pounds will be available in the turbine. The author recently had occasion to witness a careful test of a mixed-pressure turbine, and the result showed that with dry saturated steam at a pressure of 17 pounds per square inch absolute and a vacuum of 27 inches of mercury the steam consumption was 26.6 pounds per horsepower-hour, the thermal efficiency of the turbine being 0.626. From this performance 102 pounds of steam would be capable of developing 3.83 horsepower. As a live-steam turbine, working with the same initial pressure and degree of superheat as the reciprocating engine, would use 54.7 pounds of steam to develop the same power, the noncondensing engine should be credited with this amount, making its equivalent net consumption

$$120 - 54.7 = 65.3 \textit{ pounds}$$

in the same time that it formerly used 100 pounds when exhausting freely to the atmosphere.

A compound engine uses 58.7 pounds of steam for every 100 pounds used by a noncondensing engine doing the same work. Also, it has just been shown that a live-steam turbine will use 54.7 pounds of steam to develop the same amount of power which could be gotten from an exhaust turbine placed beyond and in series with the reciprocating engine, which the compound replaced, per 120 pounds of steam used. The sum of these is

$$58.7 + 54.7 = 113.4 \textit{ pounds}$$

instead of 120 pounds required by the noncondensing engine with the increased back pressure due to its exhausting into the thermal storage tanks. The same amount of work can therefore be done with 6.6 pounds less steam, an apparent saving of 5½ per cent. The real saving, however, is greater because it is impossible to so arrange matters that the load on the turbine will always be proportional to that on the engines exhausting into it. There are therefore times when the supply of exhaust steam is in excess of the turbine's requirements when it blows off at the safety valves on the storage tanks and is wasted. Conversely, there are times when there is a deficiency of exhaust steam, and the turbine's demands have to be made up with live steam. With compound engines and live-steam turbines, on the other hand, each takes from the boilers just what it requires and no steam is wasted.

Gas Explosions in Boiler Flues

Before the Oldham Engineers' Association, of England, William Ingham recently delivered an interesting lecture on the above subject. *The Engineer,* of London, abstracted the lecture and we are thus enabled to present briefly the gist of his remarks. In the course of his lecture, Mr. Ingham referred to the Distington boiler explosion which occurred on December 18, 1909, when eight Lancashire boilers were simultaneously destroyed, four exploding violently and completely destroying the other four. The boilers were fired by blast-furnace gas and beneath each gas burner at the front of the boiler a small coal fire was kept constantly burning to ignite the gas flame should this become extinguished.

At the time, there was a certain amount of mystery surrounding the explosion, and it was suggested that, as there was considerable fluctuation in the gas pressure and variation of the quality and constituents of the gas, if, after the flame were extinguished and the gas and air were discharged in considerable quantities in the flues before ignition, an explosive mixture might accumulate, and the ignition of a large volume of such mixture by the flame from the coal fire or by the flame from an adjacent boiler might cause the explosion, which would lift the boiler and cause it to explode from internal pressure in dropping down again.

Careful investigation and calculation showed, however, that the maximum pressure which could be produced by such an explosive mixture would not exceed 40 pounds per square inch if confined in a closed vessel. Immediately a boiler was lifted, however, or the brick envelop forming the flues gave way, the force of the explosion would have spent itself and the gas pressure would fall, and probably the boiler would drop on its seat again or roll over. Certainly the boilers would not be blown into fragments, many of which were hurled to great distances by this explosion.

The conclusion arrived at by the boiler-insurance company's engineers and the engineer surveyors of the Board of Trade was that this multiple explosion was caused by an excessive accumulation of pressure in one boiler due to the blocking up of the orifice leading to the safety valve in some manner not clearly ascertained.

It was Mr. Ingham's opinion that no really disastrous boiler explosion or economizer explosion had ever been due to sudden and violent combustion of an explosive mixture of gas and air. In a dozen or so of cases investigated by the lecturer, the effects all bore a marked similarity to each other. They occurred in most cases after the fires had been banked for some time. In one case the flue covers were blown away and about two-thirds of the brickwork from the top of the boiler. Another occurred in the overtop flue of a Galloway boiler. In one case the chamber of a Green economizer was blown down and the upper portion of the back end of the economizer was blown away. In all these cases it will be noticed that the results of gas explosions in boiler flues were almost invariably of a mild character, seldom doing more than finding vents for the gases by blowing down the brickwork forming the flues, or lifting up the iron plates or other coverings.

The Central Station Could Not Meet His Figures

At the March meeting of the National Isolated Plant Association, held at the Engineering Societies building, several members related their experiences with the central-station solicitor. Among the most interesting of these was the story told by the chief engineer of a large association building. The plant is of approximately 300 boiler horsepower and has a fairly high load factor, owing to the elevator service. Complete records are kept of all fuel, supplies, meter readings, etc., and all labor is charged to the proper items. As a result power is produced here for less than two cents per kilowatt-hour, including all fixed charges. Some time ago, the management was approached by the central-station solicitor who wanted a chance to submit figures for central-station service. He was accordingly given access to all the plant records and allowed to take such instrument readings as he wished; with these data he departed and promised to return within a few days with an attractive offer. A month elapsed, however, and he did not return, whereupon the engineer called up the central-station office in regard to the matter. He was informed that they were figuring upon the proposition and would be prepared to submit figures in a few days. After another prolonged wait, followed by another telephone message, the solicitor finally put in appearance and rather sheepishly informed the engineer that the central station was not prepared to offer a proposition which would better the figures of the present plant and ended by congratulating him upon the good showing.

Among the various committees appointed at the meeting was one upon "standardization," one of the duties of this committee being to draw up a standard form of records which will enable the engineer to tell at any time just what it is costing him to produce power.

Sulphur is one of the best things for hot bearings, and is often used at sea on engine guides and crank pins. It is best used in a powdered form mixed thoroughly with oil.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

A New Engine Type Alternator

The accompanying engravings illustrate the construction of a line of low-speed alternators built by the Westinghouse Electric and Manufacturing Company for mounting the revolving field magnet directly on the shaft of its driving engine or waterwheel. The field magnet (Fig. 1) consists of a steel wheel, exactly like a flywheel, the rim of which forms the yoke of the magnet, with laminated poles bolted to the face of the rim and exciting coils surrounding the cores. The magnet poles are of the usual type, having extended poletips at the faces, as indicated in Fig. 2. The poles are held on the rim by simple through bolts, no dovetails or other means than the bolts being employed. The magnet coils are composed of copper ribbon or strap wound edgewise with fireproof insulation between the convolutions.

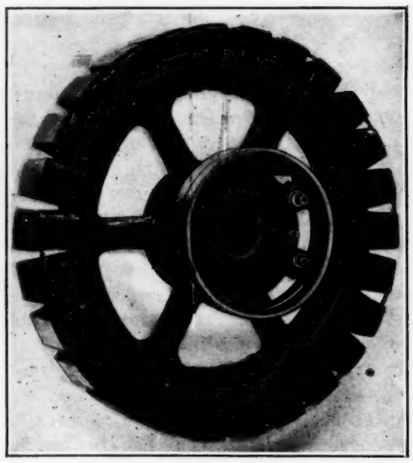


FIG. 1. COMPLETE FIELD MAGNET

The collector rings are of cast iron with radial lugs projecting inwardly. These lugs are bolted to a supporting cast-iron ring which, in turn, is bolted to the hub of the field-magnet spider, as shown in Fig. 2; the lugs are insulated, of course, from the bolts and the supporting ring. This construction obviously leaves the collector rings entirely open on the interior, permitting heat to be dissipated from the inner as well as the outer surfaces.

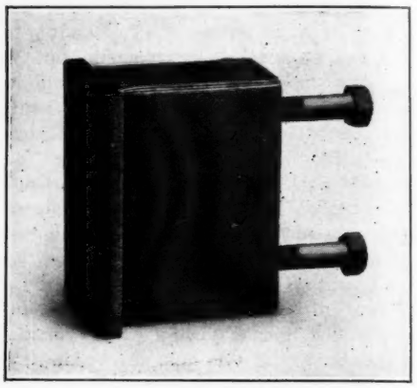


FIG. 2. A FIELD-MAGNET POLE

The armature core is built up of segmental stampings of the form shown in the upper part of Fig. 5. The dovetail projections stamped on the backs of the

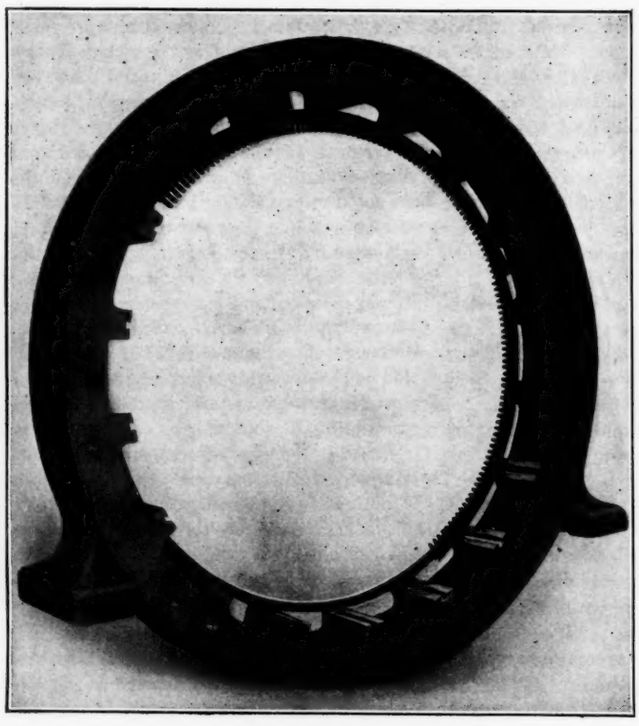


FIG. 3. ARMATURE-HOUSING RING

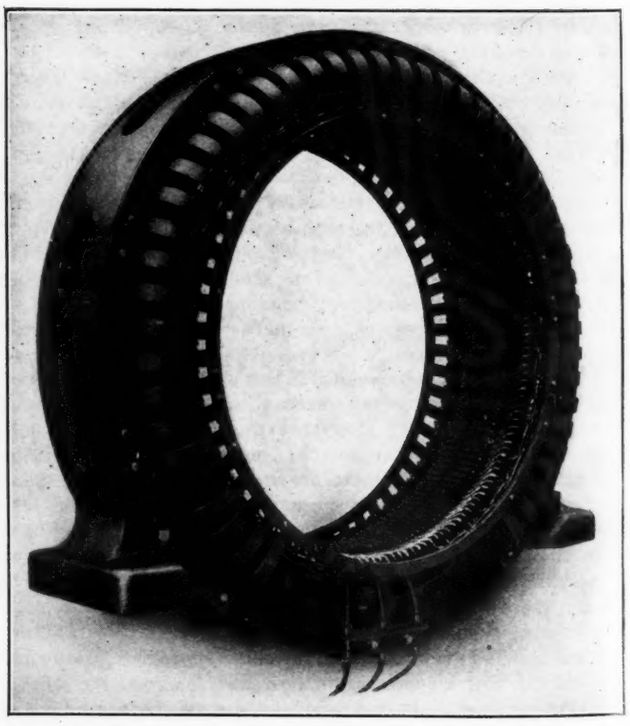


FIG. 4. THE COMPLETE ARMATURE

segments fit snugly in slots milled in ribs which extend axially across the face of the housing ring, as shown in Fig. 3. The joints between the ends of the segments are staggered in successive layers so that each joint is flanked by solid sheet on each side of its own plane. The housing or main frame is of cast iron of skeleton cross-section and ventilated by large slots cored in the center of the housing face or "rim." Fig. 3 gives a very clear view of the construction of this piece, which combines lightness, strength and ability to get rid of heat to a remarkable degree. The segmental laminations are assembled in the housing ring under pressure and held in place by malleable-iron finger plates of the shape shown at the center of Fig. 5, backed up by cast-iron end rings which are keyed to the housing. The segment shown at the bottom of Fig. 5 is a ventilating spacer. A ring of these is inserted between the core laminations at intervals, during the building up of the core, to

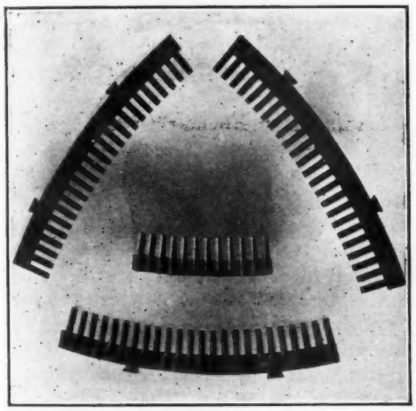


FIG. 5. CORE LAMINATIONS, A FINGER PLATE AND A VENTILATING SPACER

form ventilating ducts in the completed core.

Very close inspection of Fig. 5 will show that the core teeth are notched on each side near the free ends; these notches are to receive hard fiber strips which close the slots after the winding is in place. The armature coils are form-wound and individually insulated before being put in the slots, as is now the standard practice in the construction of machines for moderate and high voltages. After each coil is wound and shaped, it is dried in a vacuum and impregnated with a moisture-proof compound under pressure; then the wrapping is applied and finally the insulated coil is coated with an insulating varnish.

The armature or stator winding is protected from mechanical injury by steel cages or "bells" bolted to the housing ring, as shown in Fig. 4. These cages are built up of bent strips and circular segments of sheet steel riveted together.

These machines are built in sizes ranging from 50 to 1100 kilovolt-amperes and potentials of 240 to 2400 volts. They are wound for either two-phase or three-phase delivery at the standard frequency of 60 cycles.

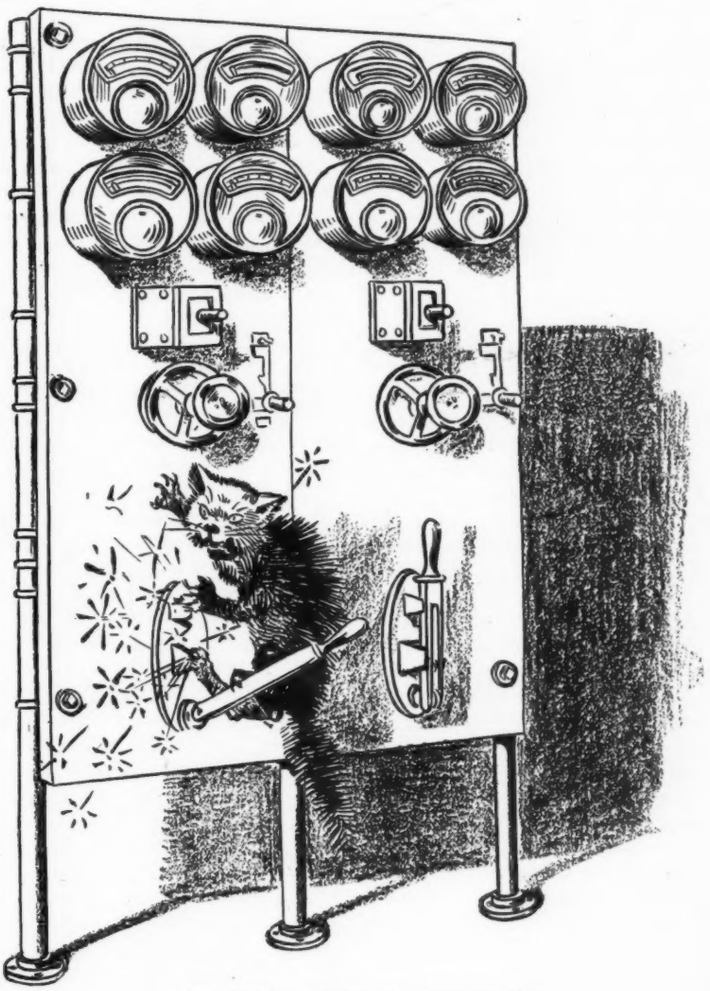
Reddy Causes a Catastrophe in the Power House

BY S. KIRLIN

Reddy's official position in the power house was that of fourth assistant to the second engineer's oiler and he was supposed to make himself generally useful in any department in which he was needed. He was about ten years old, had a freckled face and a shock of brilliant red hair which had given him his nickname of "Reddy." His wearing apparel consisted of a shirt, overalls, one suspender and an impish smile which had never been known to come off before the occurrence of the event herein related.

His duties were supposed to begin at 7 a.m., but he usually got around earlier and put in the spare time tying knots in the legs of the overalls belonging to the day shift. Then he sat in a convenient place out of their reach and offered sundry bits of advice as they struggled to untie the knots. His activities in this line finally led to agitation among the men to be supplied with lockers, and after this was done Reddy had to find other means of entertainment. The men claimed that these lockers were the only good that had ever resulted from Reddy's connection with the company; yet, if he had been discharged for any of his tricks every man in the station would have joined in a petition to have him reinstated, for life around the plant would have been very dull without him.

One of his first capers after coming into the plant was to set fire to a small piece of oily waste, lay it on the foundation of one of the engines, and then enjoy the frantic efforts of the second engineer and the oilers as they ran around trying to find a hot box. After this had happened a few times they caught him at it and the chief convinced him of the inadvisability of doing it again. He occasionally varied his tactics by abstracting fruit from the men's lunch baskets, inserting a liberal amount of red pepper in it and returning it to the baskets; the facial and lingual expressions of the victims at lunch time were his reward.



THE RESULT OF REDDY'S EXPERIMENT

This trick usually exhausted everybody's patience and the men would catch him, carry him out to the boiler room, hold his feet up and pour coal dust down the legs of his overalls. After he had accumulated all the dust that would stick they would take him out in the yard to the overflow tank in which the condensers discharged and throw him in. Reddy enjoyed the latter part of the treatment as much as any of them, but did not like the amount of work that was necessary to get the coal dust out of his pants.

He met his match one day when he tried to play a joke on Hans, the station repair man. Business had been poor in Reddy's line all the morning and he was looking for trouble. He had not been able to find an opportunity to start anything worth while until he happened to spy Hans down on his knees scraping the end of a belt which was to be spliced, the glue pot being near at hand. When he discovered Hans in this position the possibilities for breaking the monotony appealed to him at once and he began to plan the most effective way to break it. The belt driving one of the exciters was close to where Hans was working and was charged heavily with static electricity, and an overpowering curiosity induced Reddy to find out if Hans' overalls were thick enough to insulate the electricity. Going into the stock room he found a piece of heavily insulated wire, one end of which he laid on the floor, bending it up so as to come near the belt; the other end he wrapped around a stick and touched it to the seat of Hans' overalls.

Ordinarily Hans was very slow in both speech and action and had never before been known to make a sudden move, but the effect of the shock was surprising. "Gott in Himmel," he yelled, and making a violent effort to straighten up, pitched forward on the floor and upset the glue pot. Scrambling to his feet he looked around and, seeing Reddy, knew instantly the cause of his trouble. Reddy had been so surprised by Hans' sudden move that he delayed making his exit, and as he turned to run he tripped over the belt. Before he could get on his feet, Hans had him and was calling to the other men to come and see what was going to happen to Reddy. The entire station force turned out to see the show, many willing hands helping to drag Reddy back to where the glue had been spilled, and while they held him, Hans wiped up the glue, using Reddy's hair for a mop. After getting it thoroughly saturated they carried him out to the boiler room and rubbed his head in the coal pile. Reddy spent the next two hours in the overflow tank trying to wash the coal and glue out of his hair, but with poor success. Coming into the engine room he tried to complete the job with a bunch of waste soaked in gasolene while the men stood around and gave him all kinds of advice about the danger of premature ignition from getting the gasolene so near his hair.

After this strenuous experience, Reddy remained fairly quiet for a few days, but such a condition could not last long and everybody around the station was wondering where he would break out next. His success in applying electrical treatment to Hans prompted him to try it, a few days later, on old Tom, the station cat. He had often tried the experiment of rubbing Tom's fur in the dark, and knew that as a generator Tom was a success; but he was curious to know if the process were reversible and how Tom would perform as a motor in case the current should be applied to him from an outside source. As a motor old Tom proved to be a "howling" success.

Reddy found him curled up asleep on the operator's desk, which stood just in front of the switchboard panel containing the circuit-breaker and instruments controlling one of the main units that was in operation at the time. He made the connection with Tom in somewhat the same manner that he had with Hans, but the result was rather different. Old Tom let loose a blood-curling yowl and went up in the air several feet. As he came down "all spraddled out," his feet landed on the handle of the main switch; his struggles pushed the switch open and there were fireworks all along the line.

Here was where Reddy's smile faded. After the men had got things straightened out and the service had been restored, the superintendent came in and investigated. Upon learning of Reddy's experiment on the cat he took that youthful genius "on the carpet" so effectively that he didn't smile for the next hour and a half. Then the superintendent went out into the boiler room where he could laugh without Reddy seeing him.

A Big Hydroelectric Development in India

A hydroelectric undertaking has been promoted by a Mr. Tata, of Bombay, which will require a capital of about twenty million rupees (more than six million dollars). The site for the generating plant is at Lanowli, about 40 miles from Bombay, the chief commercial city of India. The waterfall has a head of about 1734 feet, which is one of the highest in the world, being ten times as great as that of Niagara and four times as great as that of Kauveri. The average rainfall in this locality is 175 inches.

The power is to be carried over a transmission line only 43 miles long at a pressure of 80,000 volts. The plant, as at present laid out, will suffice to supply Bombay in the season of least rainfall with 30,000 electrical horsepower, on a basis of 3600 working hours a year, but provision is made for enlarging the plant by developing another valley, which will bring the total power to 50,000 electrical horsepower. The company expects to be able to bring the cost of the power down to 0.55 anna (about 1 cent) per kilowatt-hour. The development is being financed entirely by local (Indian) capital.

CORRESPONDENCE

Effect of Field Adjustment on a Rotary Converter

I once installed some compound-wound rotary converters for supplying current to 550-volt direct-current power circuits. One Sunday I received a hasty message from the power house that the transformers furnishing current to the rotaries were burning up. I found the transformers smoking hot but no permanent injury had been done.

As the power load was very light on Sunday, the operator had decided that high voltage was unnecessary and therefore proceeded to weaken the field of the converter in service, causing the current to lag and increase in value until the transformers were seriously overloaded. When the shunt field rheostat was set back to the point marked for maximum power factor the transformers soon cooled down.

To those who have had no experience with rotary converters a few words explaining their characteristics which bear on this trouble may be of interest. The direct-current voltage delivered by a rotary converter bea a certain fixed ratio to the alternating current voltage supplied to it. Hence, in order to change the direct-current voltage the alternating-current voltage must be varied; altering the field strength merely alters the power factor of the alternating current. There is one field strength of a rotary converter that is called "minimum-input" field. At this point the alternating current delivered to it is minimum because the power factor is 100 per cent. To decrease the field current below this point will cause the current taken by the rotary to lag; to increase it will cause the current to lead. In either case the current is increased because the power factor is decreased. Therefore, when the operator weakened the field strength of the converter he caused the alternating current to increase sufficiently to overheat the transformer windings.

Anniston, Ala. G. J. REYNOLDS.

A feller frum over t' Jayville kum inter my ingin room tother day an' after he'd gawped at th' ingin fer awhile he ast me what th' thing wuz thet wuz whirlin' 'round so fast. I told him it wuz th' flywheel; he sed he didn't see how th' gol darnd flies cud stick to it with it goin' so fast.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

The Gas Power Boat "Holzapfel I"

There was launched recently from an English shipbuilding yard a producer-gas power boat for the Holzapfel Marine Gas Power Syndicate, Ltd. She is the first gas-power sea-going vessel to be built, and measures 120 feet in length between perpendiculars, 22 feet in breadth and 11 feet 6 inches in molded depth. She will carry a little over 300 tons on a draft of 10 feet. The vessel will be fitted with a set of high-speed six-cylinder vertical engines, developing 180 brake horsepower at 450 revolutions per minute. The plant will be in duplicate, each division being of 100 horsepower. The generators are square in section and will stand side by side on the port side of the vessel, with their "faces" to the engine room. The scrubbers, which will stand forward of the generators, are about 13 feet high, the lower portion being the wet cooler and the upper portion the dry scrubber. Both generators and scrubbers will be inclosed in a gas-tight compartment separated from the engine room, and provided with adequate ventilating arrangements.

The power of the engine will be transmitted to the propeller shaft by means of the Föttinger transformer, which reduces the revolutions of the latter to any desired number, within certain limits, while the engine is running at full speed. It can also stop or reverse the propeller while the engine is running at full speed ahead. The loss of power entailed by its use varies from 3 per cent. to 20 per cent., according to size, and to the gear or ratios of the number of revolutions of the prime mover to the number of those of the propeller shaft. A favorable ratio is from 300 revolutions of the prime mover to about 100 revolutions of the propeller shaft. In the vessel just launched the transformer is geared from 450 revolutions of the gas engine to 120 revolutions per minute of the propeller. The transformer, together with the thrust block, is coupled directly to the engine, and the total length of the two is about 20 feet.

It is expected that the consumption of anthracite coal will be from 2800 to 3400 pounds daily, as against 3½ tons of steam coal for compound steam engines of equal power. An air compressor and air cylinders will be provided for starting the gas engines. The blowing up of the gas producers while they are being fired up will be effected by air injectors supplied from the compressed-air cylinders. The vessel's average speed will be 7½ knots.—*The Mechanical Engineer.*

A Bituminous Producer Gas Power Plant

There has recently been installed at the works of S. F. Bowser & Co., Fort Wayne, Ind., a mechanically poked producer using Pennsylvania run-of-mine bituminous coal, the gas being used for operating a number of Riverside gas engines for lighting and power purposes. This producer installation, which was put in by the Holbeck Gas Power Company, of Cleveland, O., is one of the first of its type to be used for power, although this type has been in successful operation in furnace work several years.

Fig. 1 is a cross-section of the type of generator, cooler, rotary washer and dry scrubber used at this plant. It will be noted that the generator is of the updraft type and the gas passes directly from it to the cooler by a short connection lined with firebrick and provided with a manhole cover at *M*. Bituminous crushed, nut, or slack coal is fed automatically through the revolving drum *D*, which regulates the fuel according to the load.

The gas generator, which is 10 feet in diameter and rated at 750 horsepower, revolves on steel trunnions, making about one complete revolution every twenty minutes; it is driven through a gear train by an electric motor. The cast-steel poker *P* is oscillated by the gear mechanism, stirring the fire as the generator revolves. As the top remains stationary a water seal is provided at the top to prevent the escape of gas. Peep holes are provided through which to inspect the condition of the fuel bed at different points.

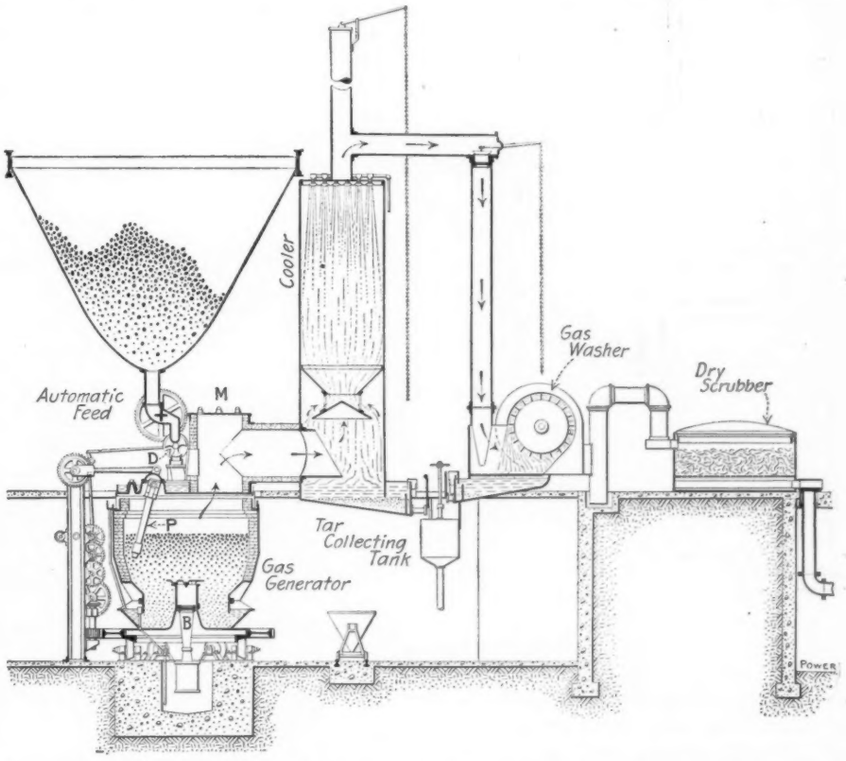


FIG. 1. SECTIONAL ELEVATION OF THE ELEMENTS OF THE HOLBECK EQUIPMENT

Ash is taken out through the lower water seal, this operation being necessary only once in 24 hours. Air and low-pressure steam are delivered to the fuel bed by the induction blower *B*, through the central tuyere immediately above it. The relation of grate area to the horsepower developed is such that at no time is a combustion rate greater than 16 pounds of coal per square foot of grate surface per hour required. No attempt is made to work at the high temperatures sometimes attained in producers. It was thought better by the designers to run at a lower temperature and make no attempt to fix the tar.

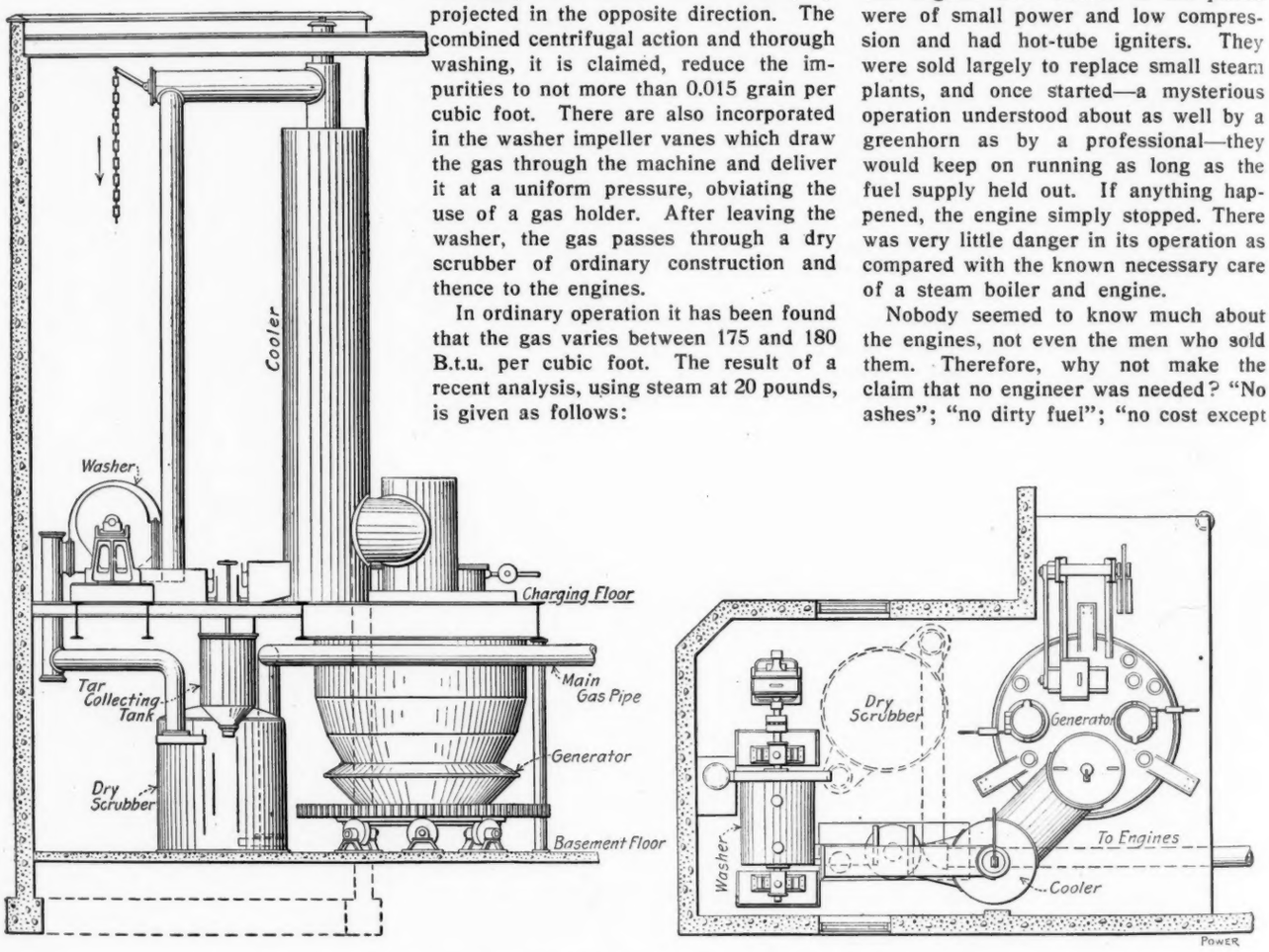
The cooler shell is a tall steel tank of simple riveted construction. In this tank the gas meets a fine spray of water discharged downward and filling the entire shell. The hot raw gas enters at the bottom and passes upward, being intimately mixed with the spray, cooled and partially purified. The tar which accompanies the gas in vaporous form is condensed and forms into tar bubbles, most of which pass off with the gas to the washer. A part of the tar, however, falls to the water seal at the bottom of the tower and sinks to the bottom, whence it is periodically drained into a tar-collecting tank.

One of the vital parts of the system is the rotary washer, which mechanically separates the tar from the gas. This is of the Saaler type; its operation depends upon centrifugal force and the fact that the gas is lighter than the tar. The gas is caught by the rapidly revolving drum and whirled at high speed; the tar bubbles, being of greater density than the gas, are thrown outward by centrifugal action into a film of water covering the inner wall of the casing. Furthermore, the vanes on the revolving drum of the washer are so placed that the gas passing through the machine comes intimately into contact with a water spray projected in the opposite direction. The combined centrifugal action and thorough washing, it is claimed, reduce the impurities to not more than 0.015 grain per cubic foot. There are also incorporated in the washer impeller vanes which draw the gas through the machine and deliver it at a uniform pressure, obviating the use of a gas holder. After leaving the washer, the gas passes through a dry scrubber of ordinary construction and thence to the engines.

In ordinary operation it has been found that the gas varies between 175 and 180 B.t.u. per cubic foot. The result of a recent analysis, using steam at 20 pounds, is given as follows:

CO	20
H	18.9
CH_4	5.6
O	0.2
CO_2	8.4

The heat value was 184.4 B.t.u. per cubic foot. This high value, it is claimed, is largely due to the low temperature at which the producer is run, which evaporates the tar and enriches the gas with some of the higher volatiles of the coal which are ordinarily burned to carbon dioxide when higher temperatures are maintained.



FIGS. 2 AND 3. ELEVATION AND PLAN OF THE PRODUCER AS ACTUALLY INSTALLED

Engineers for Gas Engines

BY CHARLES O. HAMILTON

For years salesmen—and builders, too, I am afraid—have preached the "no engineer" gospel in regard to the operation of gas and gasolene engines and there is no doubt that they and the misguided user have, in consequence, been reaping a big crop of trouble. What is the real truth about the gas-engine engineer question anyway? Why not thresh it out and settle it, now and for all time?

The "no-engineer" fallacy originated, I believe, in the early days when the gasolene engine was being introduced. The engines then offered to the public were of small power and low compression and had hot-tube igniters. They were sold largely to replace small steam plants, and once started—a mysterious operation understood about as well by a greenhorn as by a professional—they would keep on running as long as the fuel supply held out. If anything happened, the engine simply stopped. There was very little danger in its operation as compared with the known necessary care of a steam boiler and engine.

Nobody seemed to know much about the engines, not even the men who sold them. Therefore, why not make the claim that no engineer was needed? "No ashes"; "no dirty fuel"; "no cost except when running"; "no engineer." These looked like reasonable claims for the new power and were generally accepted by intending buyers as facts.

Gradually great progress has been made in gas power. Larger engines have been developed; new fuels found and used; higher compression, electric ignition, more exacting service conditions, all have followed. Now, the man familiar with steam engineering knows that the better-grade engine, with the accessories necessary for high efficiency, calls for

more ability in the operator. This is equally true with gas engines. The better they are, the more efficient and reliable, the more attachments and appliances are required and the more skill needed to operate them.

The advancement in gas-engine practice was seemingly slow but it has, in reality, been very rapid. Ten years have produced a revolution in the way of sizes, types and fuels used. Yet many of the old-school salesmen are still active and cannot seem to get over using the arguments "No engineer" and the others which are so foolish in the light of present-day conditions.

This "no-engineer" talk has made an enemy of thousands of steam engineers. Even if they knew the truth about the silly claim, their antagonism was aroused and they naturally fought back in self-defense. Many have been so blinded by prejudice that they have not even recognized the advantages that the new prime movers possessed.

Many of us gas-engine men stopped talking this "no-engineer" nonsense long ago but we are still reaping the crop of trouble sown in former days and other crops are still being sown to some extent. We are, right now, at a most trying period in the industry. It is still hard to do business and do it right. For example, if a conscientious builder tells a prospective buyer that an engineer is necessary and another builder assures him to the contrary, what show has the man who tells the truth? The prospective buyer will naturally conclude that the conscientious man's engine is too complex and difficult to run and it will be extremely difficult, if not impossible, to get him to consider it at all.

Anybody with experience with both steam and gas power knows that a good gas-power plant requires less time from the operator than a corresponding steam plant. He also knows that it requires as good or even a better quality of man to get equally satisfactory results from the gas plant. Do not overlook this distinction. Less time, but as good or better men, are needed in gas-power plants.

It may interest the reader to know that a careful canvass of over two hundred plants put in by one company, ranging from 25 to 200 horsepower, shows that the average time required daily in plants running on natural or city gas or gasolene, where other work is at hand for engineer to do, is not over two hours. About 30 to 40 minutes of the time is spent stopping and starting at morning, noon and night, and the balance in occasional trips to engine room to look over the engine, and in overhauling, taking up bearings, repairing igniters and other incidental work at convenient times. Where a suction-gas producer is used it requires about another hour for handling the producer in the morning.

The experiences in these plants show conclusively that the better the operator, the less time he takes to take care of his engine. Where the operator is a good man, the engine is a good engine always.

The necessity for an engineer in a gas-power plant certainly does exist and always will. The sooner buyers realize it, the better for all concerned. Does the present steam engineer realize what an important voice he can have in saying who the gas engineer shall be?

LETTERS

Mr. Benefiel's Generator Lining

On page 494 of the March 28 issue there is a misprint in my letter on gas-generator linings. Instead of reading: "We set the firebrick in 8 inches from the shell," it should read "3 inches from the shell."

J. O. BENEFIEL.

Anderson, Ind.

Cracked Piston Faces

In the issue of March 28, John G. Kohnsberg asks for advice about cracked piston faces. I have handled a good many pistons from small gas engines, but I have never seen one cracked in the way shown by his sketch.

If all his cracked pistons are from the same make of engine, it would look as though it was due to the design of the pistons. An examination of the crack might help one to form an opinion.

I have seen a good many pistons from engines with the valves in the top of the cylinder which have had a piece knocked right out because of the valve stem breaking; lately, some of them have been completely and permanently welded with the oxyacetylene welding torch. I am very dubious about results with brazing, Smooth-on, or soft patches.

JOHN BAILEY.

Milwaukee, Wis.

I have been having a little of the trouble that Mr. Kohnsberg asks about and I believe the best way to repair a cracked piston face is to drill holes along the crack, plugging each one as soon as drilled and drilling the next so as to cut partly into the plug just inserted.

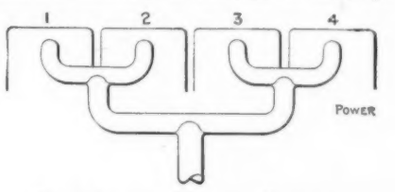
I cannot recommend this from experience, but will soon be able to report on the merits of the plan as I have charge of three 12-inch two-cylinder engines in which every piston developed a crack after about three years of service. Only one of them has ever leaked. This one I first calked with copper, which soon came out; I then used soft steel instead of copper, making small wedges which would drive tight in the crack. This has been holding tight for several months but the first time I have occasion to take the piston out I shall drill and plug it, unless someone suggests a better way.

FLOYD L. FRAZINE.

Kane, Penn.

Mr. Hall's Inconsistent Engine

In the issue for March 28, Mr. Hall wants to know why opening the pet cock on the third cylinder of his engine makes the engine run faster. It seems to me that the mixture is too rich in that cylinder, perhaps due to the piping to the intake valves not being such as to feed the same mixture to all four cylinders, and when the pet cock is opened the third cylinder gets about the proper amount of extra air to make the proper mixture. The intake piping should be arranged as shown by the accompanying sketch.



SYMMETRICAL INTAKE MANIFOLD

B. M. HOWZE.

Rural Retreat, Va.

I think if Mr. Hall will examine his engine he will find that there is a pocket in the intake pipe leading from the carbureter to cylinder No. 3, which collects some liquid gasolene. Surface evaporation from this makes the mixture too rich until it is diluted by the fresh air drawn in through the pet cock.

Another possible cause is a leak in the induction pipe which may admit air in such a way as to dilute the mixture going to the other three cylinders. Mr. Hall may have enriched the mixture to suit these cylinders and made it too rich for No. 3, which does not happen to be affected by the leakage of air. Opening the pet cock would tend to correct this.

I would suggest also that he examine the action of the exhaust valve on the third cylinder. It is quite possible that this valve opens too late or does not have sufficient lift to allow the exhaust to entirely escape and thus maintains some compression at all times unless it is relieved by opening the pet cock. I have repaired and adjusted several engines that had this trouble. If this is the trouble, it can be quickly proved by placing a thin piece of wood or iron under the end of the valve stem so as to increase the lift of the valve. If the trouble is due to insufficient lift, the engine will immediately speed up.

H. K. WILSON.

New Bedford, Mass.

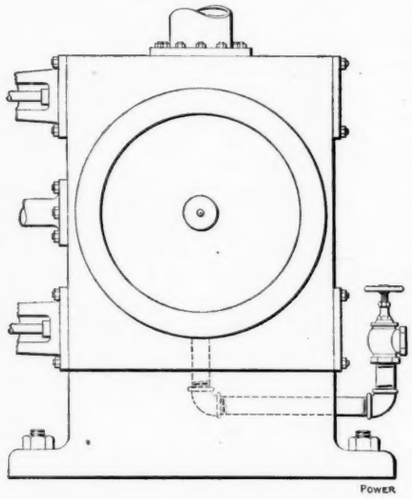
Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Unnecessary Clearance Loss

Builders of reciprocating engines recognize that clearance is a source of considerable steam loss, and design their engines so as to reduce this loss to the lowest possible amount. The erecting engineer, however, frequently makes mistakes in erecting the engine which offset much of the builder's effort toward economy.

I recently saw an illustration of this in a municipal electric-light plant, in which one of the main generating units consisted of a 350-horsepower four-valve engine. Each end of the cylinder was equipped with a 1½-inch relief valve, the openings for which were on the bottom of the cylinder. There was plenty of room to have placed these valves in an inverted position directly underneath each end of the cylinder, by simply using nipples long enough to reach through the lagging. Instead of doing this, however, the erecting engineer had connected them as shown in the illustration, putting in a trifle over three feet of 1½-inch pipe between the valves and the cylinder.



A Case of Unnecessary Piping

The total volume of this six feet of pipe amounts to something over 125 cubic inches and as this volume was added to the total clearance of the cylinder it is easily seen that it did not add anything to the engine's economy; in fact, the engine gave such poor results in this respect that it was only used when the peak load made it necessary.

S. Kirlin.

New York City.

Leaving Things Right for the Man Coming On

The duties of the men in the power plant are made imperative by the demand for satisfactory service and the assignments by the chief. Nevertheless, a man can make the duties of the man coming on the next shift difficult, although apparently leaving everything in a satisfactory condition. When leaving his shift the operating engineer should make a tour of the plant to determine the pressure on the boilers, the water level in the boilers, and to see if all engines and pumps are in proper working condition.

If an engine is running condensing, the degree of vacuum maintained should be noted, making sure that all apparatus is working satisfactorily and, if not, it should be reported to the man coming on duty so that an investigation can be made and the trouble remedied without delay.

The oiler should, as a final duty, take a trip around the engines, feeling of all bearings and running parts to see that they are not running unusually warm. If anything should be found not running right, the oiler should report it to his successor, so that he can keep a special watch of it. In feeling for hot bearing or pins, always use the back of the hand, because it is more sensitive than the front of the hand. The oiler should leave all oil and grease cups, reservoirs and lubricators full or nearly so and make sure that they are feeding. He should also leave all oil cans full and see that all drip pans are empty and wiped out. He should also pick up any waste that may have accumulated during his shift and leave everything as clean and orderly as circumstances will permit.

One of the most important duties of the fireman in this connection is to leave good fires for the next man. Sometimes in a plant where the fuel on each man's shift is weighed and kept on record, there is a temptation to leave light fires for the next man to build up. Of course, this low coal consumption looks good to the "powers that be," so the mean fireman gets the credit of being a more economical fireman than the other.

If the man coming on duty is to clean fires at the beginning of his shift, the man relieved should leave them in the right condition. He should have a heavy bed of incandescent coke in one-half of the furnace, and the other half burned almost down to the ashes. He should also have the water level as high as practicable. These conditions enable the man coming on duty to clean the fires with comparative ease and without the necessity of feeding water to the boilers during the period of cleaning.

The night fireman in a manufacturing plant should leave the fires thoroughly clean and as well coked as possible, because there is no demand for steam while the fires are coming up in the morning; the pressure quickly rises to that required for the day's run before the fires and furnaces have become thoroughly hot, consequently the day man has to get a morning's start under adverse circumstances. The morning's start is the hardest part of the day, assuming the boilers are worked at or above their rated capacity.

The night man can also help matters by having the water well up in the boilers, so that the day man will not have to feed water to the boilers until everything is in running condition. He should also leave the ashpits clean and partly filled with water, the floor swept and the lubricator or the feed pump full of oil.

J. A. Levy.

Greenfield, Mass.

Reduced Compression and Lead Saves Coal

At one time I worked in a plant in which there was a 24 and 48 by 48-inch cross-compound Corliss engine, rated at 1500 horsepower.

The economy of the plant was not bad, but the engine did not carry the peak loads at all satisfactorily. I applied the indicator and reduced the lead and compression until the engine began to run noisily. After adjusting for quiet running, the engine was let alone.

Another engine that was rated at 800 horsepower was indicated and the valves set about the same as in the first instance. The load varied considerably each day and at different times in the day. The load the next two days after

the engine had been adjusted happened to be heavy, but when I went into the fire room the firemen were taking it easy and remarked that the load was lighter than it had been. The recording instruments, however, showed that the load was being carried much more easily and the voltage held up better than formerly. Last, but not least by any means, not as much coal was being burned per kilowatt-hour as formerly by an average of 3000 pounds less of coal per day out of a total of from 70,000 to 80,000 pounds.

The engine had double eccentrics and the governor controlled the cutoff of both cylinders. The high-pressure cylinder was steam jacketed on the heads only. Saturated steam was used which, by calorimeter tests at the throttle valve under similar conditions, showed from 98 to 99½ dry.

C. B. SMITH.

South Framingham, Mass.

Vacuum Increased by Reducing Pump Speed

In the power plant where I am employed there is a condenser that is supplied with water by a rotary pump. This pump was run at a speed of 72 revolutions per minute and a vacuum of 26½ inches maintained.

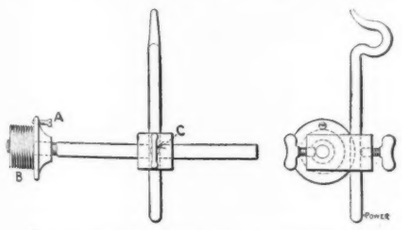
Recently, a shortage in the supply water was experienced. The speed of the rotary pump was reduced to 44 revolutions per minute, and paradoxical as it may seem the vacuum is now maintained at 28½ inches.

C. D. ELDREDGE.

Fairport Harbor, O.

Adjustable Indicator Cord Hook

The object of this device is to provide a means whereby the indicator cord can be adjusted to run parallel with the center line of the engine. The accompanying drawing shows that it is adjustable both horizontally and vertically. The pointed screw *A* passes through the flange of the plug *B* and is intended to prevent the plug from unscrewing from the crosshead in case the hook should get caught in any way, as the block *C* would turn on the long arm instead.



ADJUSTABLE INDICATOR-CORD HOOK

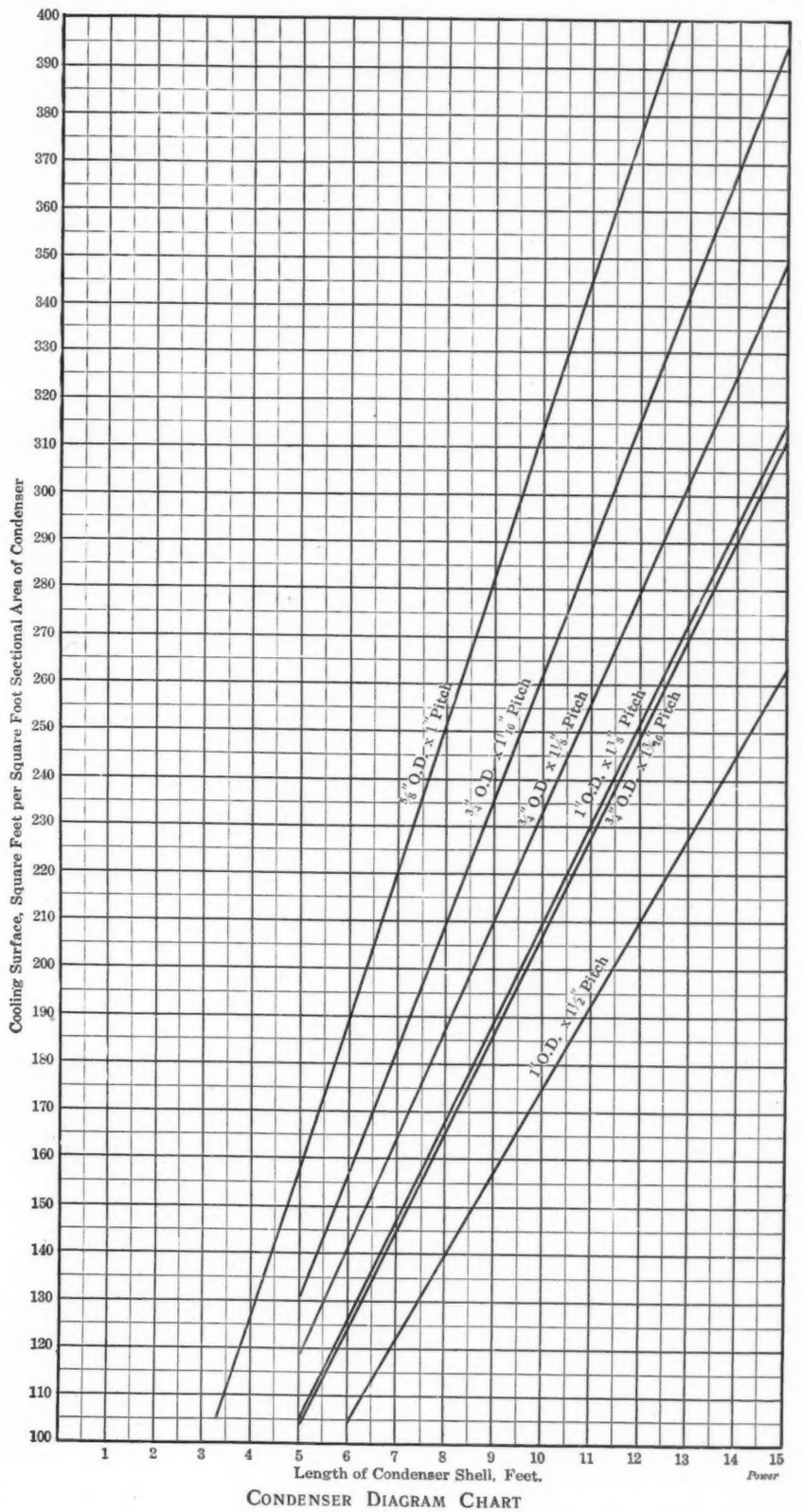
GEORGE J. LITTLE.

Passaic, N. J.

Condenser Diagram

The accompanying diagram gives curves which enable one to approximate the dimensions of surface condensers to be estimated, having been given the surface in square feet and the length of condenser shell in feet.

The tubes have a ⅜- ¾- and 1-inch external diameter, 18 Stubs wire gage thickness and a 60-degree pitch. The tubes are arranged for two passes of circulating water, but with a four-pass condenser deduct approximately 30 per cent. of the surface shown. If the steam



CONDENSER DIAGRAM CHART

dome is dispensed with, necessitating provision of steam paths between the tubes, suitable connections should be made.

This has proved of considerable value to me and doubtless will be to many engaged in the design of condensing plants.

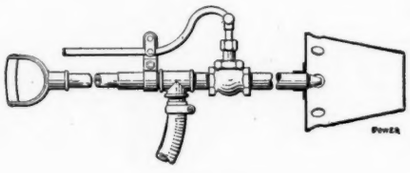
W. VINCENT TREEBY.

Goodmayes, Eng.

Homemade Tube Blower

Following is a description of a tube blower that I made from a few old fittings. The accompanying diagram shows the completed blower.

I took an old tee and screwed a short piece of pipe into it and plugged the inner end. Then a wooden handle was fitted into the other end of the pipe, an old shovel handle being used to furnish a grip. The controlling valve was made out of an old ¾-inch globe valve, with the threads removed from the stem, so it would work freely in the gland nut.



TUBE BLOWER

The valve is set so the pressure will come on top of the disk.

The blower head was made of No. 18 gage iron; the nozzle projecting about one inch into the head, which is 6 inches long. The end that enters the tube is 3½ inches, and the other end is 6 inches in diameter. It is used on 4-inch tubes.

I can blow out seventy 4-inch tubes in four minutes. A hand scraper is used once a week, the blower being used the rest of the time.

W. H. MATTHEWS.

Tecumseh, Neb.

Head End Cinders for Fuel

This is a description of the apparatus used and the results obtained in a steam-power plant using head-end cinders under the boilers. Head-end cinders are the half-burned particles of coal which are drawn out of the firebox, through the flues, and lodge behind a screen in the smoke chamber of a locomotive engine. An analysis of these cinders shows them to be a form of coke with most of the volatile matter and moisture liberated, but still very rich in fixed carbon.

The boiler under which a test was made was an ordinary return-tubular boiler of 100 horsepower capacity, set exactly as it would be set for coal burning. The grates were of the very fine sawdust type and were placed 30 inches below the boiler to provide space for the very thick fire required. The grates had 10 per cent. greater area than would have been required for coal burning.

All ashpit doors were entirely removed and the openings bricked up, leaving four 4-inch tiles protruding through and extended to about the center of the firebox. In the center of each of these tiles was placed a ½-inch pipe for a steam jet, the four small pipes being fed by a 1½-inch pipe from the boiler. These steam jets serve the double purpose of assisting combustion in the furnace by the mixing of steam with the gases, and also creating a forced draft by drawing air through the tiles in the firebox. About 10 per cent. of the steam capacity of the boiler was required for the jets.

An extra door was placed in the side of the ashpit for the removal of ashes and it was found necessary to clean the pit about once in two weeks.

To appreciate fully the results obtained in this plant it is necessary to first consider the cost and supply of cinders. This plant is located at a railroad division point where engines are cleaned out and where cinders accumulate, more than enough to supply this plant. Cinders are sold at $5 per car, regardless of the weight of the car, but the average car probably contains about five tons.

This plant has a 50-horsepower engine and a 35-kilowatt generator running from dusk to midnight and from 5 a.m. until daylight, making a total run of about 12 hours per day at the time this test was made. During the remaining 12 hours per day there was just sufficient fire under the boiler to heat the building in which it was located. The daily consumption of cinders was 3000 pounds, of which 2500 pounds were used on the lighting load and the remaining 500 pounds to keep the building warm.

The low fuel cost of this plant is apparent. The total average load was 240 kilowatt-hours per 12-hour run, which means 10.4 pounds of fuel per kilowatt-hour, not a very low fuel consumption when compared with some coal-burning plants, but an extremely economical plant when taking into consideration the low cost of the fuel. The cost of fuel averaged $0.0052 per kilowatt-hour, which compares very favorably with the fuel cost of internal-combustion engines in plants of this size.

Aside from the economy of this fuel, another great advantage was found in that it was practically smokeless, due to the fact that the volatile matter was entirely removed while in the locomotive firebox. Another advantage was the almost total absence of ash and the attendant bother and expense of the removal of same.

There are, however, some objections to this fuel, some of which are rather serious. Chief among them is the care of the fire, as the cinders are very light and quick burning and the fire requires frequent replenishing to maintain the necessary thickness; the fire must be thoroughly cleaned at least once every hour or the clinkers will get so large that the fire will have to be practically killed to take the clinkers out. Another objection is the fact that 10 per cent. of the steam output of the boiler is used to blow up the fire and, consequently, the full capacity of the boiler could not be depended upon. The life of a boiler is materially shortened by the use of this fuel, just how much I am unable to say, but I know of one boiler that was so badly crystallized after ten years' use that it had to be condemned, but this was at least partly due to lack of care of the boiler.

Taking all things into consideration there is no good reason why these cinders should not be used more in plants which are located at points where they are obtainable, provided the plant is not sufficiently large to make the necessary investment to get the highest efficiency out of a coal-burning plant a drawback.

P. E. MATTESON.

Fort Dodge, Ia.

Catalog Misstatements

Manufacturers, for a reason best known to themselves, put in at the back of their catalogs a section entitled, "Useful Information." While the body of the catalog is written by their best engineers and carefully revised and checked, this information section is a haphazard miscellaneous collection of supposed facts which I hope were not compiled by anyone higher up than the office boy.

I have often noticed rather serious errors in this section of catalogs and have now at hand three catalogs all containing the same mistake. Evidently the error was made in one of the catalogs and copied by the other manufacturers. This shows the necessity of avoiding any misstatement of facts, for, if the men getting up a catalog and who are on the lookout for errors are led into copying such a serious blunder from another catalog, how much more likely are engineers reading the catalog apt to use the incorrect figures and be led into serious mistakes.

Any one error in itself may not seem of much consequence, but the principle at stake is large, and the consequences arising from the use of such misstatements may be great. For most engineers take the statements in the catalog of a reputable concern as facts and unless they can be correctly presented, it would be much better not to present them at all.

W. L. DURAND.

Washington, D. C.

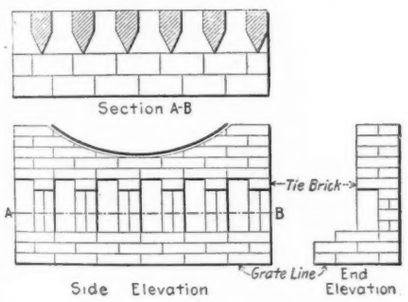
Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Furnace for Bituminous Coal

It was a pleasure to read F. B. DeMotte's letter in the March 21 issue. His thought for the welfare of the men under him is very creditable, and I feel sure that he will have their full support and coöperation.

In regard to changing from bituminous to anthracite coal, it appears to me that the price of the latter makes this impossible. Suppose anthracite containing 14,000 B.t.u. were procurable at the price mentioned in his letter. The increase in the cost of the coal would be 100 per cent. and the increase in the available heat would be only 16.7 per cent. Then, the cost of installing a fan to increase the draft and the cost of furnace alterations, together with the loss due to steam used to run the fan would



DESIGN OF BRIDGEWALL FOR AIDING COMBUSTION

probably eat up the gain due to the extra heat available from the anthracite coal.

I suggest the arrangement of a system of firebrick arches and baffles to secure smokeless combustion with the bituminous coal. The accompanying figure shows a bridgewall design of which I have a high opinion. The hot gases leaving the grate strike against the wedge-shaped bricks that are placed vertically on the bridgewall; the gases are spread out by the wedges. This results in a much better mixing of the combustible gases and more nearly complete combustion.

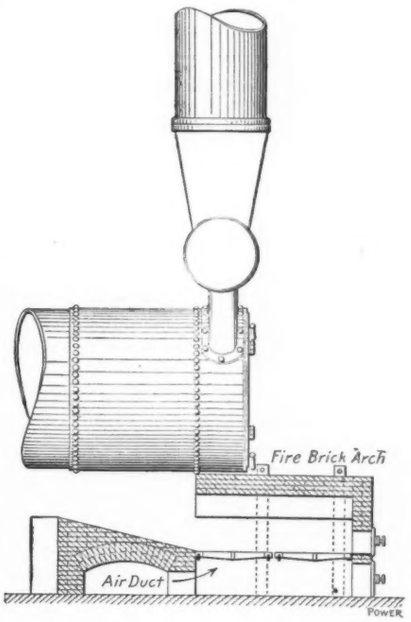
Care should be taken when installing the bridgewall to have the area of the openings at least equal to that of the tubes. The reversed arch rising around the boiler shell should be about ½ inch clear of the shell to allow for expansion. The soot found in the combustion chamber will be of a gray color and more like a fine ash, proving that combustion is quite complete.

The only way I know in which to keep the boiler house clean is to keep at it. A steam nozzle used in the chimney while the tube blower is working would certainly keep much of the dirt out of the room.

H. PREW.

Montreal, Que.

The question of F. B. DeMotte in the issue of March 21 in regard to the smoke and dust nuisance in his boiler plant is a creditable one. Wanting to improve the plant and the conditions of the fireman, he asks for the opinions of POWER readers.



DUTCH OVEN FOR BURNING BITUMINOUS COAL

If he does not have to crowd the boilers while using run-of-mine bituminous coal having a heat value of 12,000 B.t.u., a steam jet is not necessary to secure smokeless combustion. A jet should never be used for continuous operation but only applied for temporary use in cases where there are extreme demands on the boilers during short periods.

As Mr. DeMotte has ample boiler capacity, I would suggest the installation of a dutch oven, as shown in the accompanying figure. This arrangement of furnace has proved very successful in just such cases and is not expensive. The room it occupies is generally not of urgent need as there is generally at least 20 feet of space in front of the boilers as clearance for the tubes. The dutch oven takes about 5 feet; this would leave 15 feet for the firemen to work in, which is ample.

The principle of operation of the furnace is easily explained. Under ordinary circumstances the air by passing through the air duct is preheated and comes hot under the grates. In the meantime it has cooled the firebrick arch forming the roof of the duct and in that manner it lengthens the life of the arch.

The fire fed by preheated air will be a good deal hotter than under present conditions and the flame will be about 5 feet longer, giving the smoke an opportunity to burn thoroughly before striking the cold boiler shell. Under the present conditions the flames strike the cold boiler shell before the smoke formed has an opportunity to burn.

Furnaces as proposed have been very successful in preventing the smoke nuisance when the boilers were not overcrowded. They also greatly abate the dust nuisance of which Mr. DeMotte complains.

As to the use of anthracite pea coal, this does not seem advisable. It is twice as expensive as the run-of-mine now used and requires a little over twice as much draft.

RULOF KLEIN.

New York City.

Effect of Discharge Pipe Size on Motor Load

Referring to Mr. Lee's letter in the March 14 issue, it is my opinion that Mr. Lee is mistaken about the size of the discharge pipe of the triplex pump under discussion. I was assistant engineer when the pump was purchased and I helped to install it. Unless my memory does not serve me well, the discharge outlet was 3 inches in diameter and not 4 inches as he stated.

During the years that I had charge of the plant the pump motor took 5.1 kilowatts per hour.

FRANCIS J. DOYLE.

Watertown, S. D.

Water Gages

Various writers have expressed their opinions as to the different kinds of valves and their location on water-column connections.

Where the water is nearly free from scale or sediment the globe valve should give satisfaction, but if there is a great amount of scale to contend with I prefer the gate valve and would use a cross in the water connection. Instead of connecting the drain to the bottom of the cross as Mr. McGahey showed in the December 13 issue, I would connect it directly opposite the boiler connection by using a short nipple and plugged tee as an elbow and carry the drain down according to circumstances. With this arrangement there would be much less danger of scale lodging in the cross and the tee would be handy as a means of cleaning out the pipe in case of an emergency.

I see no reason for using a cross in the steam connection as very little, if any, solid matter would rise to that hight. In exceptional cases where the boiler foams a great deal a cross might come in handy in the steam connection.

WILLIAM E. PIPER.

Farmington, Utah.

The Cost of Power

I was much interested in the editorial in the March 21 issue on the cost of power and with the writer thereof regret that at the recent meeting of the American Society of Mechanical Engineers there apparently was no determined effort made on the part of the isolated-plant engineers to refute the arguments of the central-station people.

It has been my experience that the central-station salesman or sales engineer has not been overburdened with conscience when competing with the isolated plant. He has invariably used high figures for cost of installation, high coal bills, discrediting the matter of the use of exhaust steam, and has done everything possible to make the figures for the cost of power with the isolated plant appear as high as possible, bringing in many items which are rather questionable in their actual application to the situation.

There is no real reason why the generating outfit of an isolated plant should not be quite as economical in its operation as a fair-sized unit in the central station, if bought for the express purpose of low cost in power production. Frequently, however, this point is not of prime importance. The value of the exhaust steam as a means of heating water or for serving some other purpose and for heating the buildings, is of greater importance than is good steam economy of the engine. The mechanical efficiency, however, is no lower for engines for this service than any other, nor should the efficiency of the generator be any different.

When a fair-sized central station can produce a kilowatt-hour at the switchboard with 4 to 5 pounds of coal and often even less, there is no reason for assuming that a fair-sized unit in an industrial plant should not do the same. This, however, does not seem to enter into the calculations of the central-station agent, as is seen in the article by Mr. Parker, where he takes 6½ pounds of coal per kilowatt-hour as the consumption for a plant of 150 kilowatts capacity. Further, I note that Mr. Parker makes a charge of $936 against the industrial plant for emergency service, whereas in the electrically driven plant with power purchased, there is no such allowance; is the practice of central-station companies such that they can guarantee continuous service? The records of the past few years would hardly warrant any such assumption. On the other hand, the records of many individual plants are better than those of the central station, so we could reasonably wipe out the emergency-service charge or put a corresponding charge against purchased power.

I also note that the manager's time and the clerical expense are charged against the isolated plant at $1150, whereas the manager's time and clerical expense under the head of purchased power are but $25. It may be Mr. Parker's experience that no attempt is made to check the bills or to follow up the meters or to pay any attention to the cost of power as purchased. My experience, however, is different, and I believe that the proportion of manager's time and clerical expense chargeable against power in a plant with purchased power is very nearly as much, if not quite, as in an isolated plant.

I further note that the fixed charges against the isolated plant are pretty heavy, so heavy as to cause some question as to their actual fairness; I am led to question whether the central-station company makes any such charges against its own plant when it is supplying power at the low rate quoted. The central-station business is, of course, that of producing and selling power and if it invests any money in apparatus for the production and sale of power, it does it with the expectation of getting a fair return on the money, just the same as does an industrial enterprise of any character. If there is to be a charge termed profit ratio against the money invested in an industrial enterprise for production of power, in order that it may produce its goods, it would seem equally true that there should be a similar charge against the money invested in the apparatus of the central station. I decidedly question whether this is done.

It seems to me that the amortization figures would be somewhat larger for the central station than for the average industrial plant, owing to the fact that the machines are harder worked and scrapped earlier in their life to make place for new and more efficient apparatus. The taxes and interest might be somewhat smaller. My figures, comparing the central plant with the industrial plant, are as follows:

Marginal interest	5 per cent.
Amortization, so called	5 per cent.
Taxes and insurance	2 per cent.
Fair profit ratio	11 per cent.
Making total fixed charges	23 per cent.

Taking this as a basis of the fixed charges, I examined into the report of one or two of the big electric companies as given in the State report, and have taken their own figures as regards cost of plant, electric lines, transformers, meters, arc lamps, etc., and have taken their operating expenses, including operation of station, distribution of power and management. I have also taken the income as given in this report, which, according to the report, includes income from sale of current and other sources. In addition, I have taken into account the total kilowatt-hours generated and the total kilowatt-hours sold, also in accordance with the report. Against the total cost, I have made a charge of 23 per cent., leaving out, however, in this particular case, one-half of the real-estate cost, as the company owns considerable land which is not built upon and I wish to give all a fair show. From these figures I find that the average remuneration for the total kilowatt-hours generated is 4.7 cents per kilowatt-hour, and for the total kilowatt-hours sold, 6.6 cents per kilowatt-hour. Its expenses have been:

Operating, including distribution and management, 2.5 cents; per kilowatt-hour sold, 3.5 cents.

On the fixed charges, the cost per kilowatt-hour generated is 4.7 cents; per kilowatt-hour sold, 6.5 cents, making a total cost per kilowatt-hour generated of 7.3 cents, and for a kilowatt-hour sold, 10 cents.

These reports are average, but they show conclusively that there is something lacking in the method of charging if the total cost of producing power is 3.3 cents greater than the price for which it is sold. This would show, then, that according to Mr. Parker's figures and method of figuring that this company is operating at a loss. The company, however, is paying exceedingly good dividends and the stock is selling at considerably over par.

Apparently, then, the central station does not figure its costs on the same basis as it would have the individual plant figured. The average purchaser of power has not the remotest idea what his power bill is going to be. He leans entirely upon the sales agent of the central station, and in many cases goes so far as to allow the engineer of the central sta-

tion to lay out his plant, in some cases relying upon him to such an extent as to wipe out his original plant, in the firm belief that the figures given to him by the central-station sales agent will be realized. The only safe way for the purchaser of power to make a contract with the central station is on the guarantee basis of the cost of power; and if the central station will not give a contract on the guarantee basis, the sales agent is either a fool or a knave and the chances favor the latter, for the fact that he will not make a guarantee is pretty good evidence that he is certain that his figures are not correct.

The purchaser has one recourse, that is to put the matter into the hands of a disinterested party for thorough investigation, in order that he may have a careful and concise estimate of the cost of the power used throughout his plant, what it will cost him to make the changes necessary to install the electric drive, and an estimate of the cost of power as operated by electric drive with the increased fixed charges due to the added installation and the loss of the apparatus which may have to be discarded. Every item entering into the operation of the plant should be gone into, for in the northern latitudes especially the question of heat is of much importance. There often is also the item of steam for industrial purposes, for heating water for toilet and other purposes, all of which should enter the calculation. The value of the electric drive as regards its cleanliness, convenience, economy of space, uniformity of speed and the possible increase in production due to the constant speed must also be considered.

The owner should be very careful that the man he employs to examine into these details goes into them so completely as to preclude any possibility of error, and that he, the owner, thoroughly understands what the engineer has done and what his figures mean. The engineer should explain the weaknesses and possible dangers of power as supplied from the central station. It is usually claimed that central-station power is more reliable than the power generated by isolated plants. This is questionable. The engines in an isolated plant are no more liable to break down than are those of the central station, nor are the boilers. There are no long-distance transmission lines to take into account, little or no danger of electrolytic troubles, practically no danger from operating troubles in the operating station, lighting is not a factor, and on the whole there is more reason to believe that the isolated plant is less liable to interruption than the central station. The isolated plant has against it the charges in common with the central station, except the added clerical expense of solicitors for business, meters and the meter readings, the clerical expense of rendering the bills and keeping track of the accounts and the very heavy expense of distributing lines and the losses over these lines, so that in isolated plants of fair size it ought actually to cost less at the isolated plant for power than at the central station. It would have to be a plant of pretty small size that could not produce power as cheaply as the central station could deliver it to this plant, not taking into account the value of steam for heating purposes, but figuring on using the best possible type of prime mover. Then, however, taking into account the value of steam for various uses, the cost of power might be considerably reduced; first, by a reduction in the first cost of the engine owing to using a less expensive type of engine, and, second, taking into account the value of the exhaust steam which would have to be supplied anyway.

HENRY D. JACKSON.

Boston, Mass.

Valve Leakage

At various times articles have appeared in POWER on the subject of leakage through slide valves. Some of these have tended to show the advantage of the single-valve type of engine over the four-valve type using flat balanced valves.

Perhaps my experience with a pair of engines of the latter type might be of interest in that it does not agree with some of the statements made in the articles referred to above, in which it was claimed that these valves were hard to keep steam tight due to excessive wear and the large amount of clearance required between the valves and pressure plates.

In the engines of which I am writing the clearance amounts to 0.003 of an inch on the steam side and 0.0025 of an inch on the exhaust side. During ten years' time the wear on these valves was about 0.01 of an inch, which was taken up at intervals of about two years, about 0.002 at a time. The method used to determine the clearance is to shut the engine down after a run and while all of the parts are as near the working temperature as possible insert the blades of a thickness gage at different points of the valve travel.

At one time the steam valve of one engine became leaky while the exhaust remained tight and the result was the engine would run off when no load was on the generator. A few hours' work with the scraping tools stopped this trouble. This goes to prove that leakage from the steam chest to the cylinder is not entirely lost as it is when the single valve leaks steam into the exhaust passage. The amount of clearance is largely a matter of design and temperature and the wear a matter of good metal and lubrication.

The advantage of independent release and compression is well worth the extra complication, and the large ports and small clearances possible with this design more than make up for the friction of the extra parts.

P. L. WERNER.

McKeesport, Penn.

Writers among Engineers

The question has been asked why more engineers do not write of their experience.

Those that do write should at least be given credit for their intention of letting others profit by their experience, and when their letters are castigated as "hot air" and "rot," I say it is wrong and uncalled for.

In the March 21 issue, under the heading, "Specialists," Mr. Scotch tells us the class of an engineer that he is and he evidently thinks that the same class of engineer writes the practical letters to POWER.

I would like to tell Mr. Scotch that the writers of practical letters do not get their inspiration from furnaces or gas houses and that the erector or experts sent out by the manufacturer today are human and as liable to make mistakes as any other men. But, their mistakes, as a rule, do not come under the observation of the dinky one-horse engineer. The practical progressive engineer that has work going on, either repair or new installation, is onto his job and when things are not going right, whether it is the fault of the mason, carpenter, erecting engineer or laborer, he does not stop to consider how many years' experience he has had; he corrects the trouble, for that is what he is there for.

M. MEYER.

Burlington, Vt.

In the issue of March 21, Mr. Beckwith makes a good point. He asks for information in regard to getting up an article and the best subjects to write upon or rather the most acceptable ones. Here is the rub with most people, the failure to realize that many of the little, everyday happenings, the commonplace incidents of their own experience are not commonplace to many others, even to the editors, who have opportunity to see the work of many. The trouble is to get started on an article. The first word, the first paragraph is the hardest to get; the rest will come of itself. As for the subject, it is hard to assign one offhand, but here is a suggestion for a number of subjects. Just use your eyes and your ears. Look around your own "diggings" and observe how you or the other fellow does something; then find out the reason and get busy. Just listen to the questions others ask you, the experiences they tell you; it is easy to find a story, for something which will interest you while you hear it will interest others when they read it.

The shape in which you present your material to the editor is not so very important if your subject is a good, strong one, but there are a few conventions that should be observed. The following are the most important:

Write on one side of the paper only. Do not try to crowd too much on a sheet. Start a couple of inches from the top of the sheet. Leave a fair margin at the sides. Leave some room between the lines. This will permit you to make corrections without rewriting. It will also permit the editor to make corrections and will save time. Paper is the cheapest thing about an article, so it is not worth while to economize in it. Do not waste your time in rewriting; simply make all the corrections in the first draft in such a way that they can be read. If you have to make a long insertion where you have left out something, write it on another sheet of paper and mark it and the place where it is to be inserted.

Write your name and address at the top of the first sheet. Number all sheets in consecutive order. It is a good plan to give your article a title and to place that title with your name upon each sheet of the article. Then if you happen to dump the bunch of literature on the floor you can sort it out and rearrange it without much waste of time.

Remember the one-page article, one page of your manuscript, may be more useful to the editor than the forty-page manuscript. It is easy to find a place for the short article; for the long one, it is sometimes a difficulty.

Finally, do not be afraid of your spelling or the way in which you write a thing down. Remember that the compositor, aye, even the editor, is not infallible. If you have a message, get it out of your system in some way or other, and then forget it. The most important thing is to get it out.

A. D. WILLIAMS.

Cleveland, O.

Overload Boiler Test

In looking through the issue of March 21 I noticed an article entitled, "A Remarkable Overload Boiler Test." There are several things in the report of these tests that strike me as peculiar and I question some of the results given. For instance, the heat units given, upon which all efficiencies are based, are not, apparently, the result of a calorimetric test. Also, it seems to me something more than a coincidence that the grate efficiency of 97.12 per cent. should be identical to the last decimal place for both tests. I think you will find on investigation that the ashes in these tests were not analyzed and that the grate efficiency given is the result of a theoretical correction applied to the weight of the refuse based upon the coal analysis. It would indeed be remarkable if we could run a stoker of this type, or in fact any other, at the ratings given, with a grate efficiency of 97 per cent. It very likely would be closer to 95 per cent.

There is nothing very remarkable in the capacities developed, as with this type of stoker it should be entirely possible to operate the present-day boilers at 200 per cent. of rating continuously and I should think it would be well not to call this overload capacity as it seems to me that we are just learning how to burn coal and get some results out of the heating surface of the boiler.

I have in mind several recent contracts made for stokers of this type, which call for as high as 240 per cent. of builders' rating to be developed for a period of several hours.

C. W. E. CLARKE.

Boston, Mass.

Improvement Turned Down

All business men do not seem willing to take advantage of a saving in dollars and cents when it is put plainly before them. According to R. O. Warren in a recent issue they do. But, how about this:

The coal bill of the plant in which I am employed averages $82 per week. After due investigation and consideration I made the proposal to reduce the weekly bill $17 by the outlay of $500. About 80 per cent. of our work is supplying steam for drying rooms and for cylinders over which goods pass to be dried. In order to obtain proper drying it is necessary to carry a pressure of 80 to 95 pounds. After a test I found that 60 pounds pressure was enough for the power requirements but not enough for the drying. On inquiry I found that a separately fired superheater large enough for our needs could be purchased for $450 and $50 would pay for the necessary piping and fittings. This arrangement would give us 75 degrees of superheat with 60 pounds boiler pressure or about 380 degrees in the coils of the drying rooms, which is about 50 degrees higher than the temperature due to saturated steam at 90 pounds pressure. The expert from the superheater manufacturers went over the whole thing with me and agreed that the saving could be made. The saving would have been made by burning a cheaper grade of coal with which 60 pounds pressure could be maintained. In order to keep an average pressure of 85 pounds, I must burn coal costing 85 cents per ton more.

Perhaps it is not good engineering to reduce the pressure and then superheat to obtain the same results, but the saving in dollars and cents would be made and that is the main point. My proposition was considered by the firm and turned down. The reason why it was not accepted was because first cost only was considered.

HAROLD JAMES.

New York City.

Pressure and Pump Plunger

It seems to me that the reason for the breaking of the pump described by Mr. Potter in the March 28 number is very apparent if the cycle of operations be considered.

Consider the pump to be ready for operation with all of the cylinders empty and with the proper connections made to the well and to the discharge main. As soon as the pump is started the cylinders fill with water below the pistons on the up stroke. Then, on the down stroke this water is discharged and a partial vacuum is created in the cylinders above the pistons. These spaces are connected each to the other and to the well. As the supply pipe to the upper chambers was not of sufficient capacity to admit of filling them at a single stroke, the pumping had to continue a little before the upper space was filled. This finally occurred, however, and then there was a solid body of water filling the entire volume including the supply pipe back to the well. This water was in a state of constant vibration or oscillation due to the motion of the piston and the total quantity remained constant.

Suppose, now, that the supply pipe or, in fact, any portion of the system were suddenly restricted to a greater or less extent. Pressure would instantly develop which in Mr. Potter's case only found relief in rupturing the pump.

The pump which Mr. Potter described is apparently neither a single-acting plunger pump nor a double-acting piston machine but rather a hybrid affair.

T. D. HAYES.

Cambridge, Mass.

Engineers and Boiler Inspectors

I have been taking a great deal of interest in the editorials and articles on boilers and boiler inspection which have appeared in POWER from time to time.

I think that engineers should have nothing but the most kindly feeling toward inspectors. Unfortunately, there are engineers who seem to hate inspectors, who hide defects and in every possible way make it difficult for the inspectors to do their full duty.

When I am notified that an inspector will call on me at a certain time, I try to have things ready and convenient for him and I am careful to have things so that the inspector may see the boilers in the same condition as that in which they are operated—I do not touch a thing inside.

S. P. EATON.

Great Bend, Kan.

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POWER

Technical Education

The Technology Congress recently held in Boston to commemorate the fiftieth anniversary of the founding of the Massachusetts Institute of Technology also marks an epoch of engineering development unequaled during any like period in history, a development in which the technically trained engineer has played a very important part.

Fifty years ago steam engineering was in its infancy; the steam engine in small units had been applied to mill work, but the power house, as we now understand it, had not yet made its appearance. Electricity had not been applied to commercial utilities, such as lighting and the transmission of power, but instead was still a product of the laboratory. The telephone was still in an experimental stage, tunnels were yet to be successfully constructed under rivers, the railroads were undeveloped and sanitary engineering, which has been such a large factor in improving health in our large cities, was then unknown.

The engineer of that day received his training through an apprenticeship course, which, although usually thorough, was more or less narrow. However, as the engineering problems were limited in extent, this preparation answered the purpose very well. Moreover, due to the limited size and character of these projects, they could usually be planned and carried out by one man. With the enormous increase in the magnitude and the diversity in the character of engineering projects during recent years, the methods of handling them have changed, and their successful completion has been made possible only through organization. Likewise, the qualifications of the engineer have changed; his training along engineering lines must be broader and he must possess executive ability.

Previous to 1860, the colleges had offered only courses in history, literature, languages, pure science and a few of the older professions, such as medicine and law. About this time, however, a number of far-sighted men, individually, conceived the possibilities of some of the rather crude mechanical appliances then in vogue, and recognized that there was much in the realms of pure science which could profitably be applied in extending the industrial development of the country. In other words, they did not coincide with the prevailing belief that theory and practice were incompatible, but instead were convinced that the two should be made to serve the ends hand in hand. To accomplish this they recognized the necessity of systematic study and training in applied science. Consequently, through the efforts of these individuals, several of our large technical schools were founded almost simultaneously.

There is a mistaken impression in many circles that the technical schools attempt to turn out finished engineers. Such is not the case, and no reputable school will attempt to make such claims. The most they can do is to give the students a thorough grounding in the fundamentals of engineering and to train them in systematic methods of attacking engineering problems. This, combined with the experience gained in actual practice, goes to make up the successful engineer and has been instrumental in placing engineering upon an equal footing with the so-called learned professions.

Chicago Smoke

In a report of the work of the Department of Smoke Inspection from the time of its organization in October, 1907, to December 31, 1910, Paul P. Bird, chief smoke inspector, calls attention to the fact that Chicago is essentially a manufacturing and commercial rather than a residential city, and that in attempting to eliminate smoke it is not possible nor practicable to pursue any policy which will injure the interests of the railroads, shops, factories, mills, packing houses, etc., that are spread over the one hundred and ninety-three square miles of the city's area and have made Chicago what it is today.

The power and heating for this large city are practically all produced from soft coal, only about five per cent. of the total coal being anthracite and about ten per cent. semi-bituminous from the West Virginia district. The remaining eighty-five per cent. is from the local coalfields of Illinois and Indiana.

At the close of 1909 there were, according to the department, about seven thousand high-pressure boilers in Chicago exclusive of locomotive and marine boilers. Low-pressure boilers which are also a factor in the smoke question number about twelve thousand two hundred and fifty.

Further, investigation has shown that among the high-pressure plants there are on an average of two boilers to each

stack, so there doubtless are in the city limits about three thousand five hundred smokestacks connected to high-pressure boilers. Similarly there are about 1.16 low-pressure boilers to each stack, or about ten thousand five hundred smokestacks in Chicago connected to low-pressure boilers, making a total number of smokestacks for stationary purposes of fourteen thousand.

During the last few months of the year 1910, the department made a careful investigation of the subject and, as a result, estimates that there are burned annually in the city limits of Chicago, ten million tons of bituminous coal, divided as follows:

Class	Consumer	Annual Consumption	Per Cent.
1	Central district	1,500,000	15.0
2	Miscellaneous power plants	4,500,000	45.0
3	Flats	750,000	7.5
4	Domestic	650,000	6.5
5	Special furnaces	600,000	6.0
6	Railroads	1,850,000	18.5
7	Boats	150,000	1.5
		10,000,000	100.0

To burn this enormous amount of fuel fifteen to twenty thousand men are constantly employed, and as long as the smokelessness of the city depends upon the carefulness of this great number of individuals, the work of keeping them at the highest degree of efficiency will be stupendous.

As an ultimate solution of the smoke question the department recommends the centralization of plants. In every block in the central district there are from two to twenty steam plants and in the manufacturing districts each factory, no matter how large or small, has its own power-generating outfit. If, in place of this multitude of small plants, a relatively few large power houses could be installed, the result, according to the report, would be most beneficial from a smoke-prevention standpoint, as the large plants would be equipped with automatic stokers, would operate under fairly uniform load conditions and it would be an easy matter to prevent smoke.

This recommendation is made, of course, without regard to financial or commercial considerations, which might, when analyzed, prove the scheme impracticable. As a matter of fact it is generally conceded that smoke from stationary power plants will give less and less trouble as time goes on and proper supervision by the city authorities is exercised. In the stationary plant there is generally ample room to install furnaces of proper design, with large combustion areas and mixing chambers, so that it is reasonable to hope for practical elimination of the smoke nuisance from this class of plant. It is from the railroads that the greatest trouble is encountered. Railroads are credited by the department with making forty-three per cent. of the total smoke of Chicago and over fifty per cent. of the total dirt, due to cinders, ashes, etc. Electrification is advanced as the only means whereby this may be absolutely eliminated.

During the present smoke administration there has been a great improvement in the atmospheric condition of Chicago. In the "loop" district this is especially marked. When it is considered that the fourteen men whose duty it is to observe the stacks of the city, have approximately twelve hundred stacks in each of their territories, covering fourteen square miles apiece, it is truly remarkable what has been accomplished along this line.

If the amount of smoke that was being made in 1907 at the beginning of the present administration be represented by one hundred, it is stated that the smoke now made, at the end of the administration, may be represented by sixty-six.

If all of the railroads coming into Chicago should be electrified, with other conditions remaining as they are, the amount of smoke that would then be made is estimated at thirty-eight.

With all the railroads electrified, all boats in the river burning hard coal, all flats heated by gas or coke and central-station power and heating plants covering the city, the amount of smoke is placed at five; while under the best theoretical conditions, with all power electrical, and all heat electrical, or obtained from gas or coke, the smoke conditions are placed at zero.

It will be a great many years before these ideal conditions are even approximated. In the meantime the smoke administration just coming to a close, has organized and placed on a solid engineering basis, a city department, the value of which, to the citizens of Chicago, cannot be overestimated.

Electricity and the Engineer

Although electricity has now found application in most fields of industry it is still regarded by the layman with a sense of mystery. This is probably due to the fact that scientists have thus far failed to furnish a simple definition of electricity; they know how it is produced and that it follows certain well defined laws; but all attempts at telling exactly what it is have resulted in elaborate theories which only they themselves can comprehend.

Electricity, however, is not alone in this position; there are numerous other phenomena which are known only by their effects, but which are of such common occurrence as to excite no curiosity. Perhaps the most common of these is gravitation. Everyone knows that a body left entirely unsupported will fall toward the earth with a certain force, depending upon its mass. The measure of this force is called weight, a term with which everyone is so familiar that it carries with it a certain assurance of its identity; yet if one were called upon to explain exactly what gravitation is, he would probably find himself in a position similar to that of a man trying to give a definition of electricity.

Engineering, however, is not concerned with what electricity is but rather with what it will do, and this is now pretty definitely known. It is not a source of energy but is a medium for the transmission of energy, in many ways fulfilling the same uses as shafting, belts and gears; it possesses, however, much greater flexibility of application than any mechanical means. If the operating engineer would regard electricity in this sense and then become familiar with the established laws which it follows, he would find little trouble in understanding the operation of the electrical part of the plant equipment. Such knowledge is essential to the engineer of today if he is to keep pace with the increased responsibilities of his position.

Many engineers will go down without a struggle before a formula which has a logarithm, entropy, or a sine, cosine or tangent in it. It is just as simple to look up one of these quantities and to substitute the value given in the table for the letters of the formula as it is to hunt up the steam temperature corresponding to a given pressure or the area corresponding to a given diameter, and the same book which contains the tables of the properties of steam and of circumferences and areas will usually have the other things too.

The correspondents of *The Engineer*, of London, are having an animated discussion regarding the live-steam feed-water heater. Will a boiler actually deliver more steam per pound of fuel burned, if a part of the steam which it makes is used to heat the feed water to the boiling point? And, if so, why?

Investigation will show that water powers are not "gold mines" and that it costs something for their development. In fact, in many cases they cannot successfully compete with steam or gas.

Have you ever talked things over with the owner and found him a gentleman and willing to help carry out your suggestions?

There seems to be a great variety of opinion regarding the proper control of water powers. At present the Government has no definite policy except to maintain the existing status of confusion.

Have you noticed in small plants that some men leave the door between the engine and boiler rooms open when coal is being delivered and ashes removed?

"It is not so bad to be ignorant as it is to know so many things which are not true."

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Area of Pump Valves

How is the proper area for the discharge valves of a pump determined?

J. C. K.

The area should be such that at a piston speed of 100 feet per minute the velocity of the water through the valves shall not exceed 200 feet per minute, that is, the effective discharge area of all the valves should, at least, be equal to one-half the area of the piston. Some builders, however, make the valve area two-fifths that of the piston.

Ratio of Air Pump to Steam Cylinder

What should be the ratio between steam- and air-pump volume for a simple condensing engine?

J. A. L.

For an equal number of strokes in the case of a single-acting pump and jet condenser the ratio of cylinder volumes should be from 5 to 1 to 10 to 1. For a double-acting pump the ratio may be from 8 to 1 to 16 to 1, depending on temperature of injection water, hotwell temperature, terminal pressure in the cylinder, etc. For a surface condenser a double-acting air pump may have a piston displacement 1/25 of the steam piston.

Compound Engine Cylinder Ratios

What would be the comparative diameter of the low-pressure cylinder of a compound engine to develop the same horsepower as a simple engine at the same speed and steam pressure?

C. E. R.

If the work done is to be the same in both cases the number of expansions must be the same; consequently, with the same initial and terminal pressures the diameter of the low-pressure cylinder of the compound engine must be equal to the diameter of the single cylinder of the simple engine.

Energy in One Pound of Coal

If all of the energy in a pound of coal could be utilized, how much power would it develop?

E. P. C.

Coals vary in heat value, but if a pound could give up 14,000 heat units it would be the equivalent of

$14{,}000 \times 778 = 10{,}892{,}000$ *foot-pounds*

or energy enough if it could all be used to project itself over 2000 miles upward.

Dynamo and Motor Speeds

Why does a machine run at a slower speed when operating as a motor than when being driven as a dynamo, the terminal voltage being the same in both cases?

C.F.J.

Because the resistance of the armature circuit cuts down the net voltage to be balanced by the motor's counter electromotive force and adds to the electromotive force that the dynamo must generate. Suppose the armature winding and field strength to be such that the armature will generate one-tenth of a volt for each revolution per minute and the drop in the armature circuit is 5 volts at full-load current. Running as a dynamo delivering 110 volts, the armature must generate 115 volts total, to overcome the internal drop; the speed then will be 1150 revolutions per minute. Running as a motor on a 110-volt circuit, the armature drop of 5 volts leaves 105 volts to be balanced by counter electromotive force; to generate 105 volts, the speed needs to be only 1050 revolutions per minute, or 100 revolutions per minute less than the dynamo speed.

Shunt Strip of a Compound-wound Dynamo

What is the purpose of the shunt strip across the series field winding of a compound-wound dynamo?

T. B.

To adjust the proportion of the armature current that passes through the series winding and, thereby, the compounding effect of the winding. Read the "Primer of Electricity" in the February 21 number.

Proportions of a Gasolene Motor

In a gasolene motor for a small boat, what relation of bore to stroke would you advise and what compression pressure and piston speed?

J. T. W.

Make the stroke one-fourth to one-third greater than the diameter of the cylinder bore, according to how your power and speed work out. The compression pressure should not be over 70 pounds, gage; the piston speed may be anywhere from 400 to 600 feet per minute, according to your power and rotary speed requirements. The reciprocating parts must be designed in view of the speed selected as well as the pressures involved.

Ignition Current from Lighting Circuit

Can a jump-spark ignition system, using the ordinary induction coil and vibrator, be supplied from a 110-volt incandescent-lighting circuit?

J. R. L.

Not satisfactorily, unless special provision be made for reducing the voltage at the primary terminals of the coil. Simply putting resistance in series with the primary winding is not satisfactory because the vibrator has to open a 110-volt circuit instead of a 6-volt circuit. The nearest approach to a satisfactory arrangement of low cost is a resistance coil connected directly across the 110-volt circuit, the primary circuit of the ignition system being connected to the resistance coil at such points as to get 6 volts potential for the system (see accompanying diagram). This is wasteful, because current flows through the resistance coil all the time and at the full circuit voltage.

Advantages of Condensing Engine

What two advantages has a condensing engine over one which is noncondensing?

C. E. A.

Two advantages of a condensing engine over a noncondensing engine are that more power can be obtained out of a given sized cylinder and it can be obtained more cheaply; that is, for less steam per indicated horsepower-hour.

Reversing a Compound-wound Motor

What is the best way to change the connections of a compound-wound motor for reversing its direction of rotation?

S. G. R.

Exchange the connections of the cables leading to the brushholders so that the current will go through the armature in the opposite direction; do not make any change in the connections of the field windings.

Government Control of Water Powers

A continuation of the report presented in last week's number on the water-power conference held by the National Electric Light Association.

J. R. McKee: The public domain of the Government of the United States, including all the cessions from the thirteen States that made cessions and, including Alaska, amount in all to about 1,800,000,000 acres. Of this there is left as purely Government property, outside of Alaska, something like 700,000,000 acres. Of this the National Forest Reserves in the United States proper embrace 144,000,000 acres; the rest is largely arid or mountain country, offering some opportunity for agriculture by dry farming and by reclamation and containing metals as well as coal, phosphates, oils and natural gas. To the above 144,000,000 acres of forest belonging to the Government should be added 26,000,000 additional acres withdrawn in two forests in Alaska. Omitting Alaska, the 144,000,000 acres of forestry land withdrawn is equivalent to more than 27 States the size of Massachusetts.

In giving the extraordinary figure as to the amount of land in the forestry bureau, I do not understand that these figures include the 92,000,000 acres additional of land covered by document 10,860—lands withdrawn from settlement under provision of an act of June 25, 1910. Adding these 92,000,000 acres it means an additional area equivalent to an excess of 17 States the size of Massachusetts; for the two combined an area equivalent to an excess of 44 States the size of Massachusetts.

Appropriations for the support of the forestry bureau beginning with the year 1900, when they were $48,500, increased until in the year 1911 the appropriations for the support of that bureau are $5,051,000, making the total appropriations for the support of the bureau to date approximately $23,000,000. According to Congressman Edward T. Taylor from Colorado, who quoted the former head of the forest service, this forest system when it reaches its real development will require the services of 118,000 to 120,000 men.

I have taken the list of appropriations made by the last Congress and, including all of the salaries from the secretary of the forest service down to the office boy, the average salary is in excess of $1200 per year each. Assuming these same figures it means when the forest service comes to its own the salary list alone will be $144,000,000 per year. The question naturally arises in the minds of some people as to whether this is not pretty nearly a case of the Government owning its own forests and buying them over again from itself.

For the benefit of those who are not familiar with the subject, I would state that the forest reserves are established not only for the cutting of timber but are let out for pasturing. For instance, during the last year, there have been pastured on the forest reserves nearly 1½ million cattle, in excess of 85,000 horses and over 7½ million of sheep and for this the Government has received over $986,000 which, however, was less than they received the previous year from this source. From the timber sold they received just a little over $1,000,000. Taking last year's (1910) appropriations for the support of the forest bureau, which were $4,682,000, the total cost for that year's upkeep amounted to a total of $6,711,428. We all know what compound interest means and if one will take these appropriations as a start and compound the interest on them and charge them against the forest reserves and add to that the additional appropriations as they come along, it is hardly necessary to say how startling the figures will become.

I have dwelt upon these figures and this situation because I am wondering if this has not a great deal to do with the attitude of the Government officials. It is only human that those who undertake enterprises want to see them work out successfully, whether they be individuals in the Government employ or otherwise.

The 92,000,000 acres mentioned as withdrawn under the special act included those upon which it was thought there might be found coal, oil, gas or sites available for water power. Now, in regard to the latter these lands as they now stand are so tied up that it is impossible for anyone, no matter how sincere or desirous they may be of locating upon them, to get located. In other words, there is no law under which the Government can allow him to acquire possession. Suppose you found a site or parcel you would like to take up and develop and you notified the department. The President might give orders to restore this land to the public domain and let you locate upon it. What right has the President to give you preference? In other words, would he not find himself in a position similar to the one, for instance, where the Indian or other reservations are thrown open to entry and where a date is fixed and an order is given and the proposed settlers line up at the border and at the sound of a gun make a rush and the first one to arrive at the location gets it.

Mr. McKee then presented a situation not only possible but not at all improbable, showing the difficulties that might be expected in building on a navigable stream and in erecting a pole line. A brief abstract follows:

Suppose that you own by outright purchase the shore lines along a stream whereby the erection of a dam, a head suitable for the development of power can be secured. It happens that the stream in question at some point below the proposed dam, not necessarily near it, is navigable, but at the particular point where you wish to put your dam, it is impassable. In other words, there is not sufficient water for navigation and the stream is not of sufficient size to be navigated above there, although presenting the possibility that by the aid of the Rivers and Harbors Committee in the way of an appropriation, it might be made so, but whether commercially is a question. You, however, own this property and want to develop it. You must go before Congress for the privilege because it is called a navigable stream. You get an act passed granting this right and there is attached to it the stipulations that you must at the time or thereafter, if the Government so orders, construct at your own expense and on your own land, locks and operate them without expense to the Government, giving preference to whatever water there may be available without regard to what effect this may have on your power-generating plant, which, by the way, may be a serious situation during low-water periods. You have now dealt with Congress and your stipulation is that you must thereafter deal with the Secretary of War and also the Chief of Engineers.

For your transmission line it happens that adjacent to your site is a farming land where the homesteader has filed and is living in process of acquiring title. Of course, the homesteader has not yet secured his title and therefore cannot give you any right to cross his land. The Government also cannot give you any right because the land has been filed upon by the homesteader and to that extent it is beyond the privilege of the Government. So if you go across this land with your pole line it must be illegally. Adjoining the homesteader's land and also to be crossed by your transmission line is land still in the public domain. If you wish to cross this you must deal with the Secretary of the Interior, who will impose upon you such restrictions as he deems essential, such as police regulations, stipulations as to charges and limit as to time. The next land your pole line has to cross is a

forest reserve. You much now take up your negotiations with the Secretary of Agriculture who will suggest to you a use agreement with time limits and stipulations as to charges, etc., and these charges have been suggested on a basis as though your entire plant was on the public domain. Finally you reach your destination for delivery of power and it is a city where you own the electric-lighting company and you will probably come under a public-service commission who will also stipulate charges and other regulations. You now have a property to get together with which you have dealt with Congress, the Secretary of War, Chief of Engineers, a homesteader, Secretary of the Interior, Secretary of Agriculture and a public-service commission.

What is to be the solution of such a complex situation as this and is it not absolutely imperative that there shall be some solution before it is possible to persuade financial interests to undertake any such enterprises?

Personally I think that water-power sites ought to be made readily available and it should be possible for them to be taken up and developed the same as a railroad can locate on public lands, and presuming they will be developed as a public utility, which most of them certainly are, I do not see why it should not be a sufficient safeguard if they be brought under the regulations of the local authorities, the same as other public utilities. The true regulation of water powers is that which will prevail and pertain to the respective localities where they may be located. Public-service commissions are handling these questions broadly and I think that their experience demonstrates that this is the most satisfactory and the ultimate outcome of the entire situation.

Ralph D. Mershon: A discussion of this important question resolves itself into the following questions:

1. Shall the control of these hydraulic development sites lie with the Federal government, or with the respective State governments?

2. If the present Federal control be ceded to the respective State governments, shall such action be absolute or with restriction?

3. Whether the control rests with the Federal Government or with the respective State governments, shall absolute title in these sites be ultimately passed to the individual or corporation; or, shall the ultimate title remain with the people?

4. If the ultimate title be passed from the people, how shall it pass? By mere location and exploitation, or by some form of competitive purchase?

5. If the ultimate title is not passed from the people, how shall such title, as is passed, be limited as to the length of tenure and the privileges it conveys? Furthermore, what method shall be employed for determining who shall be the recipient of such title as conveyed.

My views in regard to questions 1 and 2 are that the control should be vested in the respective State governments, but that the Federal control should be ceded with such restrictions as will result in uniformity in these matters among the States. Regarding questions 3 and 4, I believe that in no case should absolute title to the water-power sites, which are at present on the public domain, be passed to individuals or corporations; that the ultimate title to these sites and all rights in connection therewith should remain with the people.

Item 5 cannot be so simply disposed of as the preceding items as individual cases will differ. It must be borne in mind that these enterprises should be attractive to capital, and ample time should be allowed in which to accumulate the necessary physical data, and in which to make financial arrangements under such conditions as will be manifestly fair toward those acting in good faith, while endeavoring to insure against mere monopolistic or speculative control.

It is held by some that the idea of a limited tenure is economically unsound and financially impracticable. I do not agree with either of these statements. Certainly at the present time no one, for either financial or economic reasons, would refuse to invest in a public-utility enterprise simply because the contract had a limited time to run. If such a limitation of tenure is unobjectionable in the case of a public utility, I can see no reason why it should be objectionable in the case of hydraulic development sites.

I believe it possible to satisfactorily and equitably handle these matters from the point of view that the rights conferred upon the individual or corporation making the developments are in the nature of a franchise, and are neither absolute nor perpetual.

As I understand it, Mr. Doherty's claim is that a limited tenure of water-power rights must necessarily result in greater cost of power and otherwise to the detriment of the consumer; that this is uneconomical and that the only course broadly economical is that of perpetual tenure in one form or another. The elements of this argument are as follows:

1. That limited tenure will make it difficult to finance and enterprise a development, which will mean a higher rate of interest and this, in turn, must be borne by the consumer.

2. That under unlimited tenure, bonds can be refunded as they fall due, thus obviating the necessity of a sinking fund, but that limited tenure will require amortization of the bonds; hence the sinking fund or its equivalent.

3. That as the end of the tenure approaches, it will be increasingly difficult to provide money for any needed extensions or improvements, with the result that either the service will be less effective or that the price of power will be higher.

The foregoing propositions are predicted upon the assumption that the physical property will at the end of the term of years pass in fee simple to the State. On such assumptions they are undoubtedly true, though the degree to which they are true will depend upon the length of tenure. I believe, however, that this assumption is not necessarily true. So far as limited tenure is concerned, objections 2 and 3 will evidently be done away with if the bonds representing the money expended in creating and extending the property carry with them the assurance that at the end of their term the principal will be paid or the property will again be available for bond issue.

The only apparent reason why limited tenure should, in itself, be productive of objection 1 is that if the enterprise were unsuccessful and they were unable to amortize the bond, they would find themselves at the end of the bond series with neither principal nor property on which to foreclose. But such contingency also will be obviated by the clause suggested for meeting objections 2 and 3.

It seems to me the conditions indicated will be fulfilled and therefore the objections met by the following clause:

This was to build and extend the plant under the State's supervision and operate it for a term of years under the State's supervision as to maintenance. Let the time be extended at its expiry or, if not extended, let the State redeem or guarantee the bond issue for the creation and the extension of the property.

I believe the majority of the people in this country are unalterably opposed to passing absolute title to these water powers to individuals or groups of individuals. It seems to me, therefore, that these gentlemen who are now opposing the policy of limited tenure had much better bow to the inevitable and cheerfully assist in devising effective plans for the carrying out of this policy. By so doing, they will be encouraged in that rapid development of water powers which they advocate, whereas their present attitude will merely serve to retard development.

Calvert Townley: I am strongly opposed to Governmental meddling with hydroelectric properties by control, regulation, by special taxes, or any other way whatsoever, except by the exercise of the ordinary police policy to maintain and uphold the law where necessary, and by the collection of the usual and ordinary taxes the same as would be collected on all other real property.

A tax on water powers can evidently be imposed only for one or both of two reasons: First, to restrict or control the development; second, to produce revenue

for the Government. It would be wrong in both counts. If a tax is to be imposed to produce revenue for the Government, it will fail in its purpose. If the rate be made so small as to have an insignificant effect upon the power company's expenses, can it have other than an insignificant effect upon the Government's revenue? And if the rate be made high enough to afford a substantial revenue it must act to deter many developments, which under the most favorable conditions might be made, and thus both keep the Government from getting any revenue and the neighborhood from any advantages which cheap power might offer toward improving that section of the country.

Public-service corporations of all kinds are now in process of being regulated and controlled. No one can say where the process will stop. Occasionally a corporation official is found who says he thinks this control will benefit his company. The very great majority, however, feel that such control will either limit their earnings or increase their expenses, or both, and thereby make their securities less attractive to investors.

It is impossible to convince the promoter who wants to invest other people's money that a water power is not a splendid investment, and it is useless to argue with the man who knows all about the subject but has not yet tried it. However, a list of hydraulic developments—real ones, those that actually have been and are now doing business—showing the amount of money put in and the amount taken out, would make interesting reading. The small percentage of earnings and the number of plants that have gone to the bad financially might astonish some of our able-bodied legislators who are afraid that somebody may make money while they are not looking.

Percy Thomas: The thing that is to be avoided is monopolistic control which will permit an original owner from reaping a tremendous profit, say, after fifty or one hundred years, when the property may have become extremely valuable.

Suppose we are going to give a fifty-year franchise for the development of a water power. The public, in addition to having fair service, etc., expects to get some rental from that. Suppose the Government is arbitrary and says—if you develop 50,000 horsepower, that shall be so much per horsepower, from the beginning to the end, each year. That would be very difficult for the capitalist. Suppose, on the other hand, the public is ready to take low rates at first, before the public demand is quite up to the full installation, and a higher rate toward the end of the term, when the consumption is fuller, and the load factor is satisfactory? That makes very little difference to the public. We will assume that the public gets the same total amount out of it, but it makes an enormous difference to the investor—he knows that he will not have to pay the taxes until he has something to pay them with.

Take the point about amortization—we have the same fifty-year term of the franchise—the public can be assured, nineteen chances out of twenty, that at the end of the fifty-year term in some form or other they will get back the money invested in the plant. At the end of the fifty years they will either agree, as a matter of reason, to extend the franchise, or make someone else pay the value of it, or force the Government to pay for it, if the Government will take it over. There is every chance that the Government will get something for it, and they might as well agree that they will take it over, as they have in the case of the New York subway. It makes little difference to the public whether or not it is arranged for in the beginning, but it makes an enormous difference to the man who has to raise the money.

If that point of view is taken by those who have the final arrangements to make, namely, that the rights of the public should be secured in such way as to be most favorable to the capitalist, and the capitalist is willing to take his security and profit in the way that will be of greatest advantage to the public, I think we will get along more satisfactorily than if each side is arbitrary and thinks its arrangement is best, and insists on something which appears to be theoretically correct.

Regulation must be arranged in such a way that the rivers which are interstate shall be protected. Take the case where a river flows from one State to another, and the development may have been made in the State in which the river flows somewhere near the border, and a profitable business built up. Now, the State which grants the franchise and the water rights to this plant has no control in the next State, and we will say, later, in the next State another water power is developed near the point at which this river leaves the second State. Now, in view of the fact that there may be pondage in the upper plant, they may store water by night for use in the day time, but if the two plants happen to be the right distance apart, the period during which no water is passed at the upper plant becomes the day period, when the maximum flow of water is necessary at the lower plant, and also the free flow of water occurring during the day in the upper plant will occur perhaps at night when in the lower plant it is of little use. Thus, if we are to have State regulation and State control of water powers, they must be secured in such a manner that one State will respect the rights and privileges already granted by another State.

Francis E. Frothingham: The public-service corporation, while it serves the needs of a great many people, serves the needs of a minority of the people, and it is right and proper, it seems to me, that many of the taxes borne should be directly levied against the public service and stood by those benefited from it, but there are other kinds of taxes which should not be so borne, such as the building of a lock in the Mississippi river development, for instance, and the giving of it to the Government, and a lot of things of that same kind, and these taxes should be distributed among all the beneficiaries. If we create a reservoir on the head waters of a stream, the beneficiaries therefrom are every power user below, and they should stand some of its cost. Every other abutting property owner, and every farmer who has land that is irrigated at high water, also benefits, as well as the navigable interests in the river, by such improvements. Therefore, these taxes should be distributed among all the beneficiaries. If the problem is gone at fairly and reasonably, I think the Government will meet us at every point, sooner or later, and all that we need is to be the source of the latest technical information and advise the Government, which, after all, wants to work to the best interests of all the people.

James H. Cutler: What we all want is the decision of this thing based on intelligence rather than ignorance, based on a spirit of fairness rather than that of self-interest, and I believe that the day is not far distant when that will be done.

It has been assumed, and I think correctly, that 3,000,000 horsepower are in the mountains of western North Carolina, and in that section, which, if the bill which has now passed Congress and has the President's signature, had not been passed and become a law of the land, the day would not be far distant when this 3,000,000 horsepower of water would be gone—and when such a power is gone, it is almost impossible to get it back again, except, certainly, at very great expense. They have been through that in France and know what it is to reforest the mountains, to get the land in condition so that the trees may grow. Now, that 3,000,000 horsepower we have saved. The difference of cost between water and steam is at least $15 per horsepower per year—3,000,000 horsepower at $15 per year means $45,000,000 per year, which would have been added to the cost of manufacture of cotton goods and other industries in the South. That might mean the difference between holding and losing a foreign market of cotton goods. That is only one section of the country. Without doubt, it is more than 3,000,000 horsepower that was in jeopardy in the West.

P. V. Stephens: There are in the Southern States over 9,000,000 horsepower which may be developed at a reasonable cost. There is a possibility of something like 25,000,000 horsepower which may be developed, with suitable

reservoirs. Only one-tenth of this has been developed at the present time. The water powers of the Southern States are their most valuable resource, and yet the least developed resource, and I think that this statement, so far as development is concerned, applies also to the West as well as to the Central States. It means that for the salvation of our resources, especially in the Southern States, we need immediate and thorough legislation which will put aside the barriers to the water-power development.

Economy in Burning Oil on Revenue Cutter Vessels

Capt. C. A. McAllister, engineer-in-chief of the United States revenue-cutter service recently presented some interesting data in the *New York Herald* on using fuel oil as a motive power. It was first tried out by Captain McAllister on the revenue cutter "Golden Gate" at San Francisco. So economical were the results obtained that it has now been decided to gradually spread the system to all the revenue-cutter vessels. The three boarding vessels in New York harbor—the "Hudson," the "Calumet" and the "Manhattan"—will soon be equipped with oil-burning apparatus.

The revenue cutter "Golden Gate" is a vessel of the ordinary harbor-tug type, and is engaged in boarding duty in San Francisco harbor. This is an intermittent duty involving daily a number of short trips around the harbor, a state of readiness to go at a moment's notice, and consequent lying at a wharf with steam up for the greater portion of the time. The tug is 110 feet long and up to six months ago was provided with a water-tube boiler of the Ward type and a triple-expansion engine capable of producing 515 maximum indicated horsepower. Last year a new Babcock & Wilcox water-tube boiler was installed and fitted for oil burning. Grates were put in place so that coal could be burned whenever necessary. A small cylindrical tank with a capacity of approximately 23 barrels of oil was installed in the fire room well up under the deck beams so as not to interfere with the removal of the boiler tubes when necessary. The burners are spaced about 2 feet apart, project 12 inches beyond the door-frame liners and slant slightly downward to within a distance of about 6 inches from the grate. The entire installation for burning oil, including the tank and its supports and all incidental expenses necessary to make the apparatus ready for use, cost $2500.

The oil supply is sufficient for four or five days' steaming under ordinary circumstances. It is obtained from a pipe line on the wharf where the "Golden Gate" is moored, and the tank can be filled in ten minutes.

The relative costs of coal and oil as fuel may be deducted from the performances of November, 1909, and November, 1910, which are given in Table 1:

TABLE 1. COMPARATIVE COSTS OF COAL AND OIL FUEL

	Nov., 1909 (with coal)	Nov., 1910 (with oil)
Hours under way a day, average	4	3
Knots an hour	8.5	3.5
Total miles cruised a day	34	25.5
Banked fires, hours	620.5	464.2
Fuel used a day, average, pounds	4,726	1,205
Fuel used a day while under way	3,600	975
Fuel used a day with banked fires	1,126	230
Cost of fuel a day for steaming	$8.40	$1.73
Cost a mile	0.24	0.069
Miles steamed a ton of coal at 8.5 knots		21.2
Miles steamed a ton of oil at 8.5 knots		58.5

From these tabulations, it would appear that the cost of oil fuel under conditions found on a revenue cutter is only slightly in excess of one-fourth the cost of coal. A further reduction in the cost of operation of the machinery due to the use of oil fuel comes from the fact that the personnel has been reduced from four to three men by dispensing with the services of one coal passer who cost the Government $674 for a year's service.

Judging by the saving indicated by the returns from the operation of the oil plant for the first quarter, there will be an annual saving in fuel alone of $2160. This, with the reduction of $674 for labor, will make a total annual saving of $2834 due almost entirely to the installation of apparatus, the first cost of which was $2500.

The following notes from the report of the engineer officer in charge of the steam machinery may prove of interest in connection with the operation of this plant.

With oil, the steam pressure can be kept stationary, as the machinery responds to unusual or varying demands. A great economy is effected through the careful use of the damper. The firebrick in the furnace act as accumulators of heat and about 20 gallons of oil will maintain steam at about 100 pounds pressure for 24 hours, so that steam may be easily held at night. From water at 56 degrees Fahrenheit, steam is raised in one hour, with the middle burner turned down as low as possible and using an inappreciable amount of oil.

The proper adjustment of the firebrick over the grate bars is important. They are laid flat and lengthwise across the grate. The first five rows back are laid close together and three extra rows are added for ordinary steaming. The remainder are laid in the same manner with a space of 3 or 4 inches between each row, depending on the amount of air required. If too much air is admitted, oil is wasted and if too little the burners give out a dark flame and sputter.

The temperature of the oil in the tank is kept at about 80 degrees Fahrenheit. It is delivered to the burners at about 150 degrees Fahrenheit under a pressure of 40 to 60 pounds, depending upon the work required. It is a California product, known as Richmond Hill oil, and its physical properties and chemical analysis are given in Table 2.

TABLE 2. RICHMOND HILL OIL

Ultimate Analysis	P.C.	Physical Properties	P.C.
Carbon	87.78	Specific gravity	0.952
Hydrogen	10.75	Flash point	190° F.
Sulphur	0.75	Fire point	280° F.
Nitrogen	0.34	Calorific val., B.t.u.	18,648
Oxygen	0.28		
Moisture	0.10		

The efficiency of the entire system is dependent on the regularity of the oil supplied. If through any cause the pump is not operated uniformly, no amount of attention will avail at the burners.

Spring Meeting of Mechanical Engineers

Preparations are actively under way for the spring meeting of the American Society of Mechanical Engineers, to be held in Pittsburg, Penn., May 30 to June 2. The headquarters during the meeting will be at Hotel Schenley and the professional sessions at the Carnegie Institute which is in close proximity to the hotel.

The first session for the presentation of papers will be on Wednesday morning on the subject of "The Mechanical Engineering of Cement Manufacture," following which there will be an opportunity to visit the plant of the Universal Portland Cement Company through invitation of its president, E. M. Hagar. The special train to this plant will stop at East Pittsburg, giving members an opportunity to visit the Westinghouse works. On Wednesday evening there will be a session on "Machine Shop Practice" at which the subjects of assembling small machine parts and the development of milling cutters will be discussed.

On Thursday morning the session will be very short with miscellaneous papers, after which an excursion on the river is planned. In the evening will be the reception and dance.

On Friday morning there will be papers relating to steel-works machinery with especial reference to blowing engines and forging presses. Friday afternoon will close the convention with excursions provided for that afternoon.

A session is also planned for the gas-power section.

Previous to this meeting the American Foundrymen's Association is to convene in Pittsburg and the exhibit of foundry appliances, under the auspices of the association, will be held over during two days of the meeting of the American Society of Mechanical Engineers.

New Power House Equipment

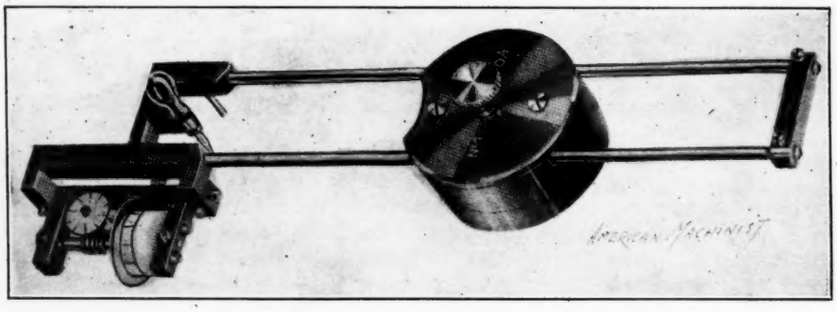
What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

Durand Radial Planimeter

The illustration herewith shows a form of radial planimeter developed to meet a demand for a type of instrument which will give a mean value of the ordinates of a circular diagram or dial instrument in measuring and recording engineering quantities such as pressure, temperature, electric voltage, current, electric power, flow of water, etc., in the same manner as does the ordinary planimeter for a diagram in rectangular coördinates.

It contains the following geometrical elements: (1) A base which is to be centered with the diagram or chart to be averaged, and carrying a pair of parallel guide slots. (2) A pair of rods working in the slots of (1) and carrying at their end a frame to which is attached a tracing point and a pivoted carriage for the integrating wheel. (3) The integrating wheel for measuring the record.

The line joining the tracing point with the center of the base determines the radius vector at any one instant. The axis of the integrating wheel is parallel with this line. Under these conditions it is easy to show mathematically that the record counted on the integrating wheel will be proportional to the product of the average radius vector multiplied by the angle through which the radius vector is carried. Hence by dividing the reading by the angle the mean radius vector is obtained. The instrument is graduated to give mean ordinate in linear inches, so that by applying the appropriate scale factor it may be used for all diagrams no matter what may be the character of the engineering quantity recorded. The limits for the movement of the tracing point are from a circle of 1.5 inches diameter as a minimum to a circle of 10.5 inches diameter as a maximum. This form of instrument is made in Switzerland by Amsler, Laffon & Co., and its American introduction is in the hands of W. L. Durand, 929 K street N. W., Washington, D. C.



DURAND RADIAL PLANIMETER

Randall Graphite Sheet Lubricant

This graphite sheet lubricant is a mechanical device the purpose of which is to eliminate friction in engine journals or other babbitted boxes. The lubricating element is composed of graphite that is held in bond in the form of tapered cones which are attached by hydraulic pressure to a fine copper-wire screen, as shown in Fig. 1.

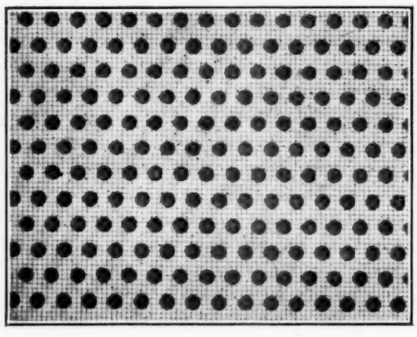


FIG. 1. WIRE SCREEN CONTAINING GRAPHITE CONES

Anyone who is capable of pouring babbitt into a box can install this lubricant, as it is only necessary to use sufficient soft-copper wire to bind the sheet so that the surface of the graphite cones will be held tight against the shaft, as shown in Fig. 2. The babbitt metal is then poured as with the ordinary bearing.

When a bearing has been finished ready for use it has the appearance as shown in Fig. 3, the black places indicating the graphite cones.

The idea of this arrangement is to get the graphite in the right place and keep it there. This combination of graphite and babbitt metal is suitable for long or short bearings, and especially for high-speed machinery where the bearings have a tendency to heat.

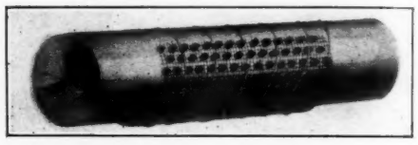


FIG. 2. WIRE AND GRAPHITE CONES AGAINST SHAFT READY FOR BABBITT

In order to show how simple it is to babbitt a box with the graphite sheet lubricant the following directions are given: A strip of the lubricant is cut wide enough to reach not quite half around the journal so that it will not reach quite to the top of the box, as shown in Fig. 2. It is then shaped by hand to a half circle a little smaller than the journal to be babbitted and placed on the journal so that the straight rows of graphite cones will run lengthwise of the box, and secured as already explained. The small ends of the cones should always be placed next to the journal so that the wire cloth will be embedded in the babbitt near the bottom of the box. This also produces a greater lubricating surface to the journal as the babbitt wears away.

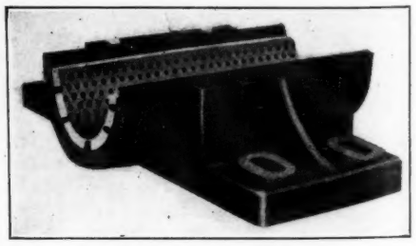


FIG. 3. BABBITTED BEARING. BLACK PLACES INDICATE GRAPHITE CONES

The Randall Graphite sheet lubricant is manufactured by the Strong, Carlisle & Hammond Company, 326 to 339 Frankfort avenue, Cleveland, O.

The Connersville Condenser

Although a rotary pump has hitherto received little consideration as a vacuum pump, it offers particular advantages for high-vacuum work.

The Connersville condenser, in which a modification of the well-known Connersville cycloidal blower is used as a pump, is shown in the accompanying engraving. Looking at the end elevation, it will be seen that there is an uninterrupted communication between the condensing chamber and the vacuum portion of the air pump. That for the water is well shown in the end elevation. The air is taken off above the discharge of the condensing cone by two air pipes shown in the plan and delivered below the center of the pump by cored passages, one of which is shown in section in the front elevation. As the lobes of the pump revolve they entrap portions of the water and air in the way made evident in the end elevation, and carry them around to the delivery side; and as the lobes revolve at a speed of from 100 to 300 revolutions per minute, depending on the size, with six deliveries to a revolution, the gaseous and liquid contents of the condenser are removed as fast as they accumulate and in a practically continuous stream. The communication between the air space of the condenser and the volume that is cut off by each lobe is so direct that any degree of exhaustion which the pump is able to produce will exist throughout. Although the rotating lobes do not come into contact with each other nor with the sides of the cylinder, there can be no air leakage backward, as all of the points of possible leakage are water sealed, and the water is being hurried along to the delivery side. Even the shaft stuffing boxes are water sealed and do not have to be packed against a vacuum. What water leakage may occur at the point *A* is unimportant so long as no air can get back.

The Connersville Blower Company, of Connersville, Ind., has furnished these pumps for jet condensers alone for an aggregate capacity of over 60,000 horsepower, but has recently developed the condenser illustrated herewith on its own account. As shown in the end elevation, the condensing water is received in a chamber *B*, of sufficient volume to retain without interruption to the service such stones and other bodies as are sometimes brought in, preventing them from passing to the pump. A handhole *D* furnishes access to this chamber without breaking any of the connections. The water filling this chamber overflows into the condensing cone through the annular space *C*, so large that it will not be clogged by grass, eels, etc.

Rolling down the inside it forms a hollow cone of water, into the interior of which the steam is received and condensed, striking nothing but water-covered and water-jacketed surfaces. The air and uncondensed vapors are carried forward by the velocity acquired by the rush of the steam into the vacuum, drawn together and delivered through the throat into the lower part of the condenser, where they collect above the water in the chamber *E*. The body of constantly renewed cold water in the chamber *B* immediately above serves not only to water jacket the upper part of the condenser and to keep it cool, but to cool the air and condense the vapor in the chamber *E*, which is exposed to the effect

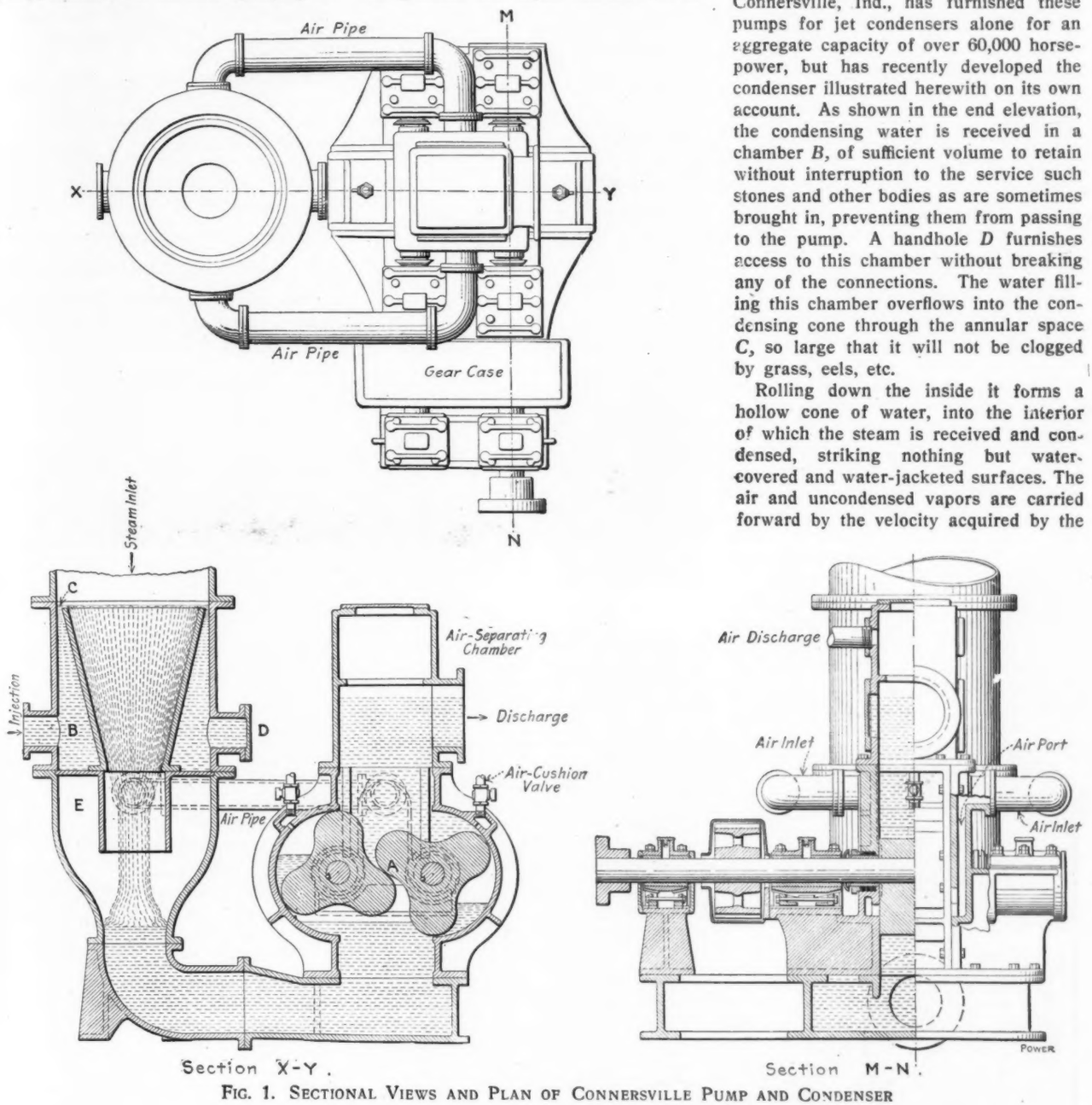


FIG. 1. SECTIONAL VIEWS AND PLAN OF CONNERSVILLE PUMP AND CONDENSER

of the division wall cooled by the direct contact of the entering water and the contiguous exterior wall surfaces, cooled by conduction. This cooling of the air is very desirable as it reduces its volume and the work of compressing it to and discharging it against the pressure of the atmosphere is measured by its volume, and not by its weight.

The water and the air are thus handled independently, allowing of this natural separation and cooling, and yet by a single pump having no valves, springs or small working parts. The pump can handle very hot water and maintain a vacuum very close to that corresponding to the temperature. Piston pumps are handicapped in this respect, because the pressure in the pump cylinder is necessarily less than that outside the valves, due to the resistance of the valves and ports, and to the differential pressure necessary to overcome the inertia of the water and make it follow the increasing movement of the piston. When, therefore, in a piston pump the vacuum is carried near to that corresponding to the temperature of the water, the higher vacuum inside the pump cylinder causes reevaporation of the water in the cylinder, filling the pump with steam and causing it to race.

RESULTS OBTAINED FROM TWO CONNERSVILLE PUMPS

Pump No. 3.

Temperature of Inlet Water.	Temperature of Discharge Water.	Load in Kilowatts.	Speed of Vacuum Pump.	Barometer.	Vacuum Mercury Gage.*	Vacuum Referred to 30 Bar.	Theoretical Vacuum at Discharge Temperature.	Per Cent. of Theoretical Vacuum.
66½°	93½°	1500	108	29.43	27.55	28.12	28.36	99.15
66⅝	93⅝	1550	108	29.43	27.55	28.12	28.36	99.15

Pump No. 4.

66½°	96½°	1200	118	29.40	27.40	28.00	28.18	99.37
66⅜	95	1400	118	29.43	27.55	28.12	28.27	99.47
66⅜	95	1600	118	29.43	27.35	27.92	28.27	98.76
66⅛	95	1550	118	29.43	27.30	27.87	28.27	98.57
62	78.8	800	104	29.86	28.6	28.74	28.93	99.34

*Vacuum gage attached to low pressure end of turbine.

The accompanying table shows the results obtained with two of these pumps, 24x20 inches, having a displacement of 56 gallons per revolution, running in the power station of the Memphis Consolidated Gas and Electric Company, at Memphis, Tenn. These readings were taken on June 10 last and represent regular running conditions. When used as a dry-vacuum pump, the cycloidal rotary type can handle any amount of water up to its full capacity without injury. When used as water pumps, the larger sizes have shown an efficiency of 84 per cent. of the indicated horsepower of the engine driving the pump. These condensing units are now available in all sizes from 100 horsepower up.

An air-separating chamber is provided on the discharge side of the pump, so the air and water can be discharged separately if desired.

The air-cushion valves on each cylinder are used to admit atmospheric air, so as to produce gradual rise to atmospheric pressure in the closed chambers, and prevent the water volumes meeting in a vacuum and producing a water hammer.

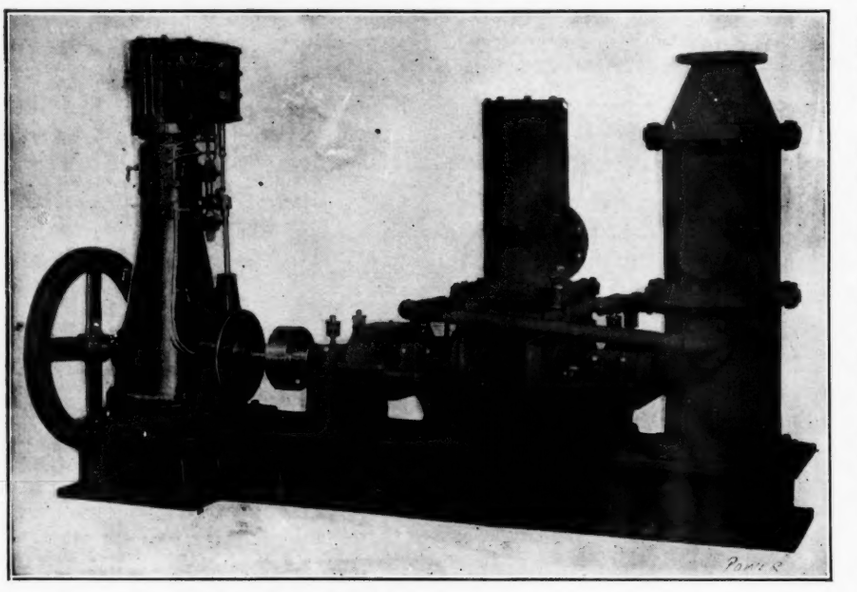
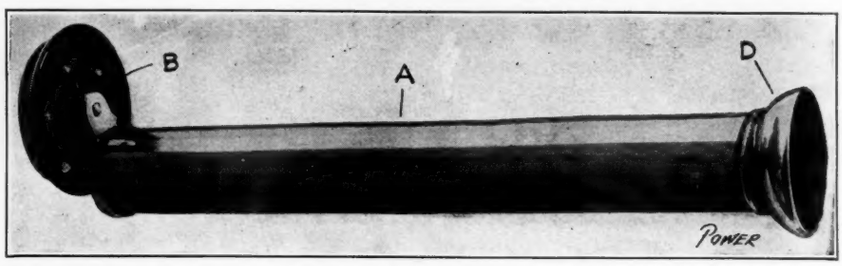


Fig. 2. Pump Direct Connected to Vertical Engine

Smoke Tintometer

This smoke tintometer consists of a tube *A*, having at one end an eye piece *D*. The opposite end of the tube has two object apertures and in front of one is fixed a revolving diaphragm *B*, having five circular openings of the same diameter as one of the object apertures of the instrument. Four of the apertures are glazed with tinted glass corresponding to, and graduated from the standard tints of the Ringlemann smoke scale, while the first aperture remains clear.



Smoke Tintometer

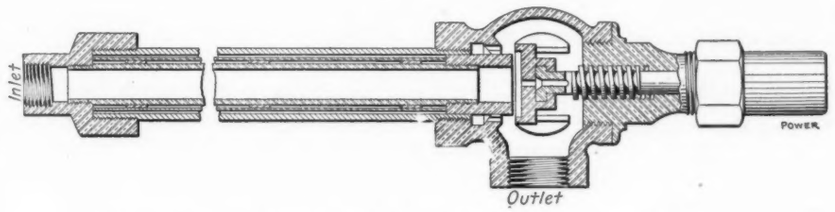
When examining the smoke from any particular chimney, the observer turns the instrument so that the aperture which is fitted with the revolving diaphragm looks toward the windward side of the smoke so that through this aperture he sees past the side of the smoke to the clear light of the sky beyond; or the same light which is illuminating the smoke column. Through the other aperture the observer sees at the same moment a circular patch which appears to be cut out of the column of smoke that it issues from the chimney. All that the observer has now to do is to revolve the diaphragm until both apertures appear to have equal illumination and a glance at the numbered scale on the instrument shows the number corresponding to "light gray," "drak gray," "black," etc., of the Ringlemann chart.

The tintometer is manufactured by John Lowdon, Reform street, Dundee, Scotland.

The Barton Expansion Steam Trap

The Barton trap consists of an inner and an outer expansion tube, into the inner tube of which the steam flows from the intake end. The inner tube at the outlet end supports the valve seat, which butts against the valve disk. When filled with live steam the inner tube is held by its expansion against this valve disk and is sealed. When condensation takes place the tube contracts and draws away from the valve disk, allowing the escape of the water, and closing again immediately after the discharge is made.

The outer tube, also an expansion tube, makes possible the use of the trap both with a vacuum or a gravity system, as follows: With a vacuum system there is maintained between the inner and outer tubes a vacuum, which insulates the outer from the inner tube, so that the outer tube is always cooler than the inner, and the inner tube takes care of the condensation, as already described. When the vacuum pump ceases to work, or where a gravity system is used, the outer tube is acted upon more directly by the steam



SECTIONAL VIEW OF THE BARTON EXPANSION STEAM TRAP

flowing from the coil, and by its expansion opens the valve by drawing the valve disk away from the valve seat on the inner tube. The inner tube has a greater coefficient of expansion than the outer, so that when the water has escaped under these conditions the inner tube will expand sufficiently to reach the valve disk and close the outlet.

This trap is placed in a horizontal position at the lower end of the coils to be drained so that the water of condensation will flow to the trap. The end of the coil must be connected to the small opening in the trap marked "inlet."

This trap is manufactured by John W. Barton, 2707 Vestry avenue, Cleveland, O.

Idle boilers should be thoroughly washed out and dried. Trays with unslaked lime should be placed inside and the boilers should be closed air tight. If the boiler is to stand ready for immediate use it should be filled with water to which burnt lime has been added, but unless the boiler is one of a battery and is kept warm, it is likely to condense atmospheric moisture from outside and corrode if filled with water.—*Ex.*

Convention of the National Association of Cotton Manufacturers

The semi-annual convention of the National Association of Cotton Manufacturers was held in Boston on April 12 and 13 and was largely attended. A number of interesting papers were read upon textile matters and one upon "Power from Producer Gas" was of particular interest. The honorary medal was awarded to Charles T. Main, of Boston, in recognition of his services as a mill engineer and for his paper upon the "Choice of Power for Textile Mills," which was delivered at the fall meeting. Franklin W. Hobbs, of Brookline, Mass., was reëlected president of the association.

Technology Congress

On April 10 and 11 the alumni of the Massachusetts Institute of Technology held a reunion at Boston to commemorate the fiftieth anniversary of the founding of their alma mater. The exercises were opened with an address by President Maclaurin, of the Institute, which was followed by the reading of a number of papers upon various engineering subjects, some of which will follow in a later issue.

The congress ended with a banquet in Symphony hall at which a number of men prominent in public, educational and engineering circles, responded to toasts.

The Institute was founded in 1861 by Professor Rogers, and from a small beginning with one building and only a handful of students, it has grown to be one of the leading technical schools with an enrollment of over fifteen hundred students and numbering among its graduates some of the most prominent engineers of this country.

Turin Exposition

In connection with the Turin International Exposition, which opens on April 29, 1911, there will be held an international competition for internal-combustion engines as applied to agriculture, entries closing on April 30. The object is to extend to various branches of agricultural work the use of petroleum motors, benzine motors, illuminating-gas motors, crude-oil motors, etc., in connection with plowing, sowing, harvesting, irrigating, etc. Various societies offer prizes, and the Italian government will purchase the articles winning first prizes in classes 1 and 2. Copies of the program for the competition in question may be obtained from the Bureau of Manufactures.

NEW PUBLICATIONS

ENGINEERING DIRECTORY. 1911. Compiled and published by the Crawford Publishing Company, Chicago, Ill. Leather; 1381 pages, 4x6¾ inches. Price, $5.

This is the eighteenth annual publication of this work which was formerly known as the "Domestic Engineering Directory." The book aims to be a complete directory of the plumbing, heating, lighting, power plants and mill-supply industries in the United States. It contains a list of wholesale dealers in plumbing, heating and lighting supplies; a list of jobbers and dealers in mill, steam, mine and railway supplies, tools and machinery and, in addition, mailing lists of water works and gas companies, power plants, wholesale dealers in hardware and electrical supplies and purchasing agents of railroads, besides a classified list of the products of these various manufacturers. The various directories appear to be complete, and the book as a whole should prove of value to those interested in the fields mentioned.

STEAM TURBINE. By Walter S. Leland. Published by the American School of Correspondence, Chicago. Cloth, 129 pages, 6¼x9½ inches. Illustrated. Price, $1.

The book was written for the practical man who, though perhaps less interested in the finer points of theory than in the results and the way in which they are secured, is still deeply interested in the fundamental principles, both of construction and operation. No comparisons have been made between the designs of the different types. Facts have been stated and the reader has been left to draw conclusions on all points where a difference of opinion might occur.

The first few pages are devoted to the history of the turbine and a discussion of the kinetic principles upon which it is designed.

All types are accurately described and illustrated, making with its practical discussion of various installations and their respective performances, a comprehensive and valuable standard of reference. Turbine speed regulation is intelligently and thoroughly covered in the last chapter.

THE TEMPERATURE-ENTROPY DIAGRAM. By Charles W. Berry. Published by John Wiley & Sons, New York, 1911. Cloth; 410 pages, 5x7½ inches; 127 illustrations. Price, $2.50.

This is the third edition of Professor Berry's excellent little textbook, which

is now expanded into a treatise on graphical thermodynamics, within the limits set by the title. In this edition the chapter on the Θ-Φ diagram for the flow of fluids has been expanded nearly four pages by a discussion of the total heat of dry saturated steam, based on Doctor Davis' classic determinations. The chapter on gas-engine cycles contains twenty additional pages devoted to the effect of different methods of speed regulation upon the efficiency at underloads and an analytical comparison of the several gas-engine cycles; the one on the nonconducting steam engine (Rankine cycle) has been improved by elaborating the tables of Rankine efficiency and specific steam consumption and extending their range downward to cover steam-turbine conditions. The old chapter of 16 pages on refrigeration and the Kelvin warming engine has been developed into two chapters covering 36 pages, one on each subject. An entirely new chapter on entropy analysis in the boiler room has been added and there are also short tables of Napierian and common or Briggsian logarithms at the end of the book.

For the benefit of those who are not familiar with previous editions it may be well to say that the book is an ideal college text but not at all adapted to "home study" or useful as a practical reference book.

SOLENOIDS, ELECTROMAGNETS AND MAGNET WINDINGS. By Charles R. Underhill. Published by D. Van Nostrand Company, New York, 1910. Cloth; 350 pages, 5x7½ inches; 221 illustrations; many tables. Price, $2.

This is the first adequate exposition of the principles and practice of electromagnet design and construction thus far published, unless one has been brought out by the Chinese, Turks or Russians. It is a pity, therefore, that the author did not either omit the purely academic phase of the subject or submit his work to a competent editor. Some of his fundamental definitions are obscure and some statements based on them are absolutely wrong. His style is neither lucid nor fluent.

The practical formulas and data contained in the book are priceless to anyone who has much to do with making electromagnets. Unfortunately, some of the charts are so small and poorly reproduced as to be useless, notably those on pages 314, 315 and 316.

Notwithstanding the weak points, the book is highly praiseworthy in general. It could be improved by condensation and the omission of didactic material. A man who needs a practical manual on this subject has passed the strictly elementary grade.

At the recent exhibition held by the Physical Society, of London, A. C. Cossor showed an improved form of W. R. Cooper's patent speed indicator. A glass tube, branched below like the traditional anchor, is partly filled with mercury and is turned together with its vertical spindle within the cup, which holds it, by the flexible drive. The liquid above the mercury in the long, central tube falls when the device is rotated; should the maximum speed that can be recorded be exceeded, no harm would be done; the liquid would simply not descend more. The motion is taken from a shaft through a friction wheel. The new type of X-ray tubes of A. C. Cossor is provided at the anode with several radiating disks of aluminum intended to cool the anode. The bulb is further fitted with a branch tube, which serves as a regulator. This tube contains a length of a smaller glass tube wrapped with asbestos, over which aluminum wire is coiled; inside the tube is a strip of aluminum, and wires from this strip extend outside to near the terminals of the bulb. The idea—first applied by Gundlach, we believe—is that too strong currents will liberate an air bubble from the asbestos lagging as soon as a spark passes from a terminal to the branch circuit; the liberated air would enter the main bulb.—*Engineering.*

SOCIETY NOTES

The second annual meeting of the American Association of Refrigeration will be held in the "east room" of the La Salle hotel, Chicago, Ill., on May 9 and 10, 1911. The first session will be called to order at 10:30 a.m., Tuesday, May 9.

On Thursday evening, April 13, J. C. Jurgensen delivered a paper on the "Economic Aspects of the Institute of Operating Engineers," before the New York branch No. 1 of district No. 2, in the Engineering Societies building. The meeting was attended by some 70 members and friends.

On Saturday evening, March 25, the members of the Institute living on Long Island, met at the rooms of the Modern Science Club and organized the Isherwood branch No. 2 of district No. 2. The officers elected were: F. L. Johnson, chairman, and Frank Martin, secretary-treasurer. This branch starts out under extremely favorable circumstances as it is made up largely of the men interested in the education at the Modern Science Club during the past winter.

On Thursday evening, May 11, at eight o'clock, the second monthly meeting of the New York branch No. 1 of the Institute will be held in the Engineering building. F. L. Johnson, associate editor of POWER, will deliver a paper on the "Necessity for Industrial Education."

PERSONAL

A. Bement, consulting engineer, has moved from the Fisher building, Chicago, to 206 South La Salle street.

Alex. Crawford has been appointed purchasing agent for the Hyatt Roller Bearing Company, of Newark, N. J., and assumed the duties of the office on April 17.

Rodman Gilder, secretary of the Crocker-Wheeler Company, of Ampere, N. J., has resigned to become associated with the brokerage house of Dick Brothers & Co., 30 Broad street, New York. His seven years' experience in a high-class industrial concern should be of value to him in the analysis of bonds of industrial and other corporations.

BOOKS RECEIVED

CURRENT RAILWAY PROBLEMS. By Samuel O. Dunn. Railway Age Gazette, New York. Paper; 85 pages, 5x6¼ inches.

THE IGNITION HANDBOOK. By H. R. Van Deventer, Sumter, S. C. Paper; 73 pages, 4¾x7½ inches; 40 illustrations. Price, 50 cents.

THE PRINCIPLES OF SCIENTIFIC MANAGEMENT. By Frederick W. Taylor. Harper & Bros., New York. Cloth; 77 pages, 6x9 inches.

ENGINES AND BOILERS. By W. McQuade. D. Van Nostrand Company, New York. Cloth; 87 pages, 5¼x8¼ inches; 62 illustrations; indexed. Price, $1.50.

THREE-PHASE TRANSMISSION. By William Brew. D. Van Nostrand Company, New York. Cloth; 178 pages, 5¼x8½ inches; 82 illustrations; tables; indexed. Price, $2.

MACHINE SHOP MECHANICS. By Fred H. Colvin. McGraw-Hill Book Company, New York. Cloth; 172 pages, 4¼x6¾ inches; 116 illustrations; tables; indexed. Price, $1.

THE TEMPERATURE-ENTROPY DIAGRAM. By Charles W. Berry. John Wiley & Sons, New York. Cloth; 393 pages, 4¾x7¼ inches; 125 illustrations; tables; indexed. Price, $2.50.

HIGH-EFFICIENCY ELECTRICAL ILLUMINANTS AND ILLUMINATION. By Rollin W. Hutchinson, Jr. John Wiley & Sons, New York. Cloth; 278 pages, 5x8 inches; 147 illustrations; indexed. Price, $2.50.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power

HAVE you ever considered the power of advertising and the wide variety of its modern applications?

About a month ago several of the churches in a certain district of Brooklyn combined to hold union services for a number of weeks. Only one church in the neighborhood was not included, and the attendance at this one quickly dropped to a very few staunch standbys. The pastor saw that something must be done to meet the competition so he secured the services of a very fine contralto and advertised that she would sing in his church every Sunday night. Since then he has had to have rows of chairs put in back of the regular pews.

Advertising is used in almost every field of work today.

It has elected candidates to office, carried bond issues at the polls, raised money for charity, stopped strikes, populated towns, cities and states.

Advertising is one of the most powerful of modern institutions. *It is our great national antidote for stagnation.*

Suppose some manufacturer today should stop improving his product and let it fall behind the times, and suppose his rival kept on making all the improvements that progress, new discoveries and new ideas made possible.

How long would the first be able to stay in business?

Not many moons—and why?

Because competitive advertising would soon point out the widening chasm between the old, stagnant product and the up-to-date, improved article.

Advertising is a goad—in its lexicon there's no such word as "quit."

It forces the whole manufacturing world to keep on the jump—to do new things—to evolve new ideas—to better quality—to make honest prices.

To those who conscientiously use advertising as a salesman, it brings great business returns.

To those who "read, mark and inwardly digest" advertising, it gives the power and ability to buy wisely, reasonably and profitably.

The rule must work both ways, or it won't work either.

"A good article, good advertising, good results for the buyer"—that's the formula—and you can't supply a "bad" for any one of those three "goods" and get away with it!

Cultivate your acquaintance with the ads in your paper—they are put there at great expense, for your benefit.

BUSINESS ITEMS

Announcement is made of the purchase by the Nashua Machine Company, of Nashua, N. H., of the Bundy steam trap business of the American Radiator Company, effective May 1, 1911.

After being located for over 30 years at 71 John street, New York, the main office of Jenkins Brothers, on April 17, was removed to 80 White street, between Broadway and Lafayette street. The business had entirely outgrown the old accommodations and necessitated securing much larger quarters.

The Lunkenheimer Company has recently opened a new branch store at 138 High street, Boston, where it is carrying a full line of Lunkenheimer engineering specialties. William W. Beal is in charge of the store, which occupies a very prominent corner on High street, and the windows present an attractive display of the various specialties made by the company.

What is said to be the largest single stoker installation in the United States is at the plant of the Cambria Steel Company, Johnstown, Penn. This installation consisted entirely of stokers of the over-feed type. After giving a Taylor gravity under-feed stoker a severe trial for a year with a low-grade Pennsylvania bituminous coal, the company has ordered three more Taylor stokers. How well the Taylor stoker stood the severe service tests is shown by a third order for 12 additional stokers.

The Wheeler Condenser and Engineering Company, of Carteret, N. J., has recently been awarded the contract for building five large surface condensing equipments. The condensers proper will all be of the Wheeler drytube type. The equipments will differ from previous condensers in the special design necessary to handle enormous amounts of steam, at the same time securing high vacuum and high rate of heat transmission through the surface. Three of these equipments are for the Waterside No. 1 plant of the New York Edison Company, and will consist of circulating, hot-well and vacuum pumps together with specially designed base condensers to operate in connection with three 20,000-kilowatt turbo alternators. These condensers will have a rated capacity of 300,000 pounds of steam per hour, and will be the largest of their kind in the world. The other two equipments, for 10,000-kilowatt turbines and with pumps and other auxiliaries, are for the new power station of the Minneapolis General Electric Company.

NEW EQUIPMENT

The New Bedford (Mass.) Cotton Mills will install boilers.

Shelby, Mont., is planning to install a new waterworks system.

Magog, Que., will establish a 1500-horsepower electric plant.

The Jamestown (N. D.) Gas Company will reconstruct its plant.

Lowell, Mass., is considering installing a municipal lighting plant.

Dudley & Hodge, Revere, Mass., will install boiler, engine and pumps.

Colby Academy, New London, N. H., will install a new power plant.

Athol, Mass., has voted $30,000 to establish a waterworks system.

Mountain Home, Cal., is planning to install a new waterworks system.

Longmeadow, Mass., will install a 25- to 30-horsepower gasolene engine.

Putnam, Conn., will spend $30,000 on improvements to its water system.

Yale University, New Haven, Conn., will install a central lighting plant.

L. F. Neuweiler & Son are erecting a five-story brewery at Allentown, Penn.

Moosejaw, Sask., will purchase two electrically driven centrifugal pumps.

Newport, N. Y., has voted to expend $15,000 to improve its waterworks system.

The Union Ice Company, San José, Cal., will build an addition to its plant.

Middlebury College, Middlebury, Vt., will make additions to its power plant.

Longmeadow, Mass., is contemplating the erection of a new pumping station.

Newburyport, Mass., will install a 3,000,000-gallon high-duty pumping engine.

The Olympia (Wash.) Brewing Company will erect a new plant at Salem, Ore.

The Lake Erie Provision Company, Cleveland, Ohio, will erect a new packing plant.

Everett, Wash., is planning to install a waterworks system to cost about $600,000.

The Westminster Granite Company, Providence, R. I., will erect a new boiler house.

Renfrew, Ont., will spend $100,000 for equipment for a new municipal power plant.

The Westport (Conn.) Water Company will enlarge its plant and install new equipment.

The Lake City Ice Manufacturing Company, Cleveland, Ohio, will enlarge its plant.

The Housatonic Power Company, South Norwalk, Conn., will build an addition to its plant.

The Philadelphia (Penn.) Racquet Club will build an addition and install several new dynamos.

The Shenandoah (Iowa) Artificial Light, Power, Ice and Heat Company will install an ice plant.

The Mt. Hood Railway and Power Company, Portland, Ore., will erect a large pumping plant.

North Mankato, Minn., will install a waterworks system for which $20,000 bonds have been voted.

Winnipeg, Mass., is in the market for a horizontal turbine pump of $2,500,000 gallons daily capacity.

The Cleveland (Ohio) Electric Illuminating Company is making a number of additions to its substations.

The Sumpter (S. C.) Lighting Company will make improvements. New transformers will be installed.

Springfield, Ore., is planning the erection of a distributing station for its proposed municipal lighting system.

The plant of the Monarch Cold Storage Company, 40 East Michigan street, Chicago, Ill., was destroyed by fire.

The Marion Water Company, Marion, Ohio, has increased its capital stock and will make additions and improvements.

The Dorchester Waste Company, Boston, Mass., is in the market for a 125-horsepower horizontal return-tubular boiler.

The Conservative Realty Company, San Jose, Cal., will be in the market for cold-storage equipment for new hotel.

The Panhandle Electric Railway and Power Company, Spokane, Wash., is planning to build a $2,000,000 power plant.

The Girard estate will erect an electric-lighting and heating plant at Twentieth and Oregon streets, Philadelphia, Penn.

The Interstate Stone Company, Leland street, Providence, R. I., will build a 200-horsepower steam plant on Park avenue.

The Bowker Fertilizer Company, Elizabeth, N. J., will increase the capacity of its power plant. New boilers, etc., will be installed.

L. S. Atkins, of Center, Tex., has been donated a site at Alto, Tex., on which an electric-light and ice plant will be erected.

Robert Smith and Fred Stanley, of Portland, Ore., are erecting a 12-story office building for which power equipment will be needed.

The Oregon Power Company, Eugene, Ore., is planning to make improvements in its power station, at Albany, to cost $100,000.

The city of Stoughton, Wis., will buy the water and electric plant of the Stoughton Mill Company and make extensive improvements.

The city of Morehead City, N. C., will receive bids until April 20, for waterworks. G. D. Canfield, chairman, waterworks committee.

C. D. Holley, Tulare, Cal., at the head of the Holley Electric Company, Porterville, will erect a steam auxiliary power plant at Tulare.

The Forest City Brewing Company, Cleveland, Ohio, is erecting an addition and will install an ice machine of 80 tons daily capacity.

Power-plant equipment will be needed for the 12-story hotel to be erected for J. A. Sanders, Cleveland, Ohio. F. W. Striebinger, architect.

The Baltimore & Ohio Railroad is erecting a cold-storage warehouse in connection with its new produce yards on Sharp street, Baltimore, Md.

NEW CATALOGS

Chard & Howe, 253-255 Front street, New York. Folder. Graphite oils.

Allis-Chalmers Company, Milwaukee, Wis. Bulletin No. 1042. Generators. Illustrated.

Lytton Manufacturing Company, Inc., Franklin, Va. Folder. Boiler blow valve. Illustrated.

Cincinnati Gasket and Packing Company, 1536-38 Plum street, Cincinnati, Ohio. Circular. Water gage. Illustrated.

Dillon-Gates Company, 2443 Olive street, Kansas City, Mo. Booklet. Automatic flue blower. Illustrated, 3½x6 inches.

Akron Metallic Gasket Company, 274 Park street, Akron, Ohio. Catalog. Metal gaskets. Illustrated, 16 pages, 5x6½ inches.

Autoforce Ventilating System, 53 Devonshire street, Boston, Mass. Pamphlet. Autoforce ventilator installations. Illustrated.

Ferd Bauer Engineering and Contracting Company, St. Louis. Catalog. Water-cooling towers. Illustrated, 48 pages, 6x9 inches.

The Carlyle-Johnson Machine Company, Manchester, Conn. Catalog E. Friction clutches. Illustrated, 36 pages, 4½x7 inches.

The Foos Gas Engine Company, Springfield, Ohio. Catalog. Gas and gasolene engines. Illustrated, 48 pages, 8x10½ inches.

Smooth-On Manufacturing Company, Jersey City, N. J. Pamphlet. Extracts from Smooth-On Instruction Book. Illustrated, 16 pages, 3½x6 inches.

De Laval Steam Turbine Company, Trenton, N. J. Pamphlet. Steam turbines for high and low pressure. Illustrated, 24 pages, 3½x6 inches.

HELP WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—Experienced foreman engineer for sugar refinery; credentials required. Apply P. O. Box 1660, Vancouver, B. C.

ENGINEERS WANTED to solicit for the Rolin patent adjustable grate. Apply Standard Grate Co., Heed Bldg., Philadelphia.

WANTED—Thoroughly competent steam specialty salesman: one that can sell high-grade goods. Address "M. M. Co.," POWER.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn Street, Chicago.

AGENTS WANTED for first-class steam specialty in use throughout United States. Address C. S. Wood, 410 S. 15th St., Philadelphia, Penn.

WANTED—Competent salesman familiar with New York and Boston territory to sell high pressure steam boilers, both tubular and water tube. Address Box 422, POWER.

SALESMAN calling at power plants to handle as a side line superior packing for steam, different from the rest and better. Nugget Packing Co., 185 Summer St., Boston, Mass.

WANTED—An engineer in each city as agent for a high class water-back Scotch boiler, the most economical steam generator known to the trade. Kingsford Foundry & Machine Works, Oswego, N. Y.

ENGINEERING SALESMEN wanted for our Chicago and Cincinnati offices. Apply respectively, Schutte & Koerting Company, 805 Security Building, Chicago, and 12th and Thompson Sts., Philadelphia.

WANTED—High class engineer with first class license to take charge of a strictly up-todate 300 Kva. plant in the city of Detroit; state salary, references, experience and where license is held. Box 425, POWER.

WANTED—A second engineer capable of handling steam and gas power in electric light and power plant of 400 horsepower capacity; state age, qualifications, salary expected and send references; applications to be in by May 15, 1911. E. Roberts, Secretary-Treasurer, Wetaskiwin, Alberta.

WANTED—A first class representative in Pittsburg to handle a reliable high speed engine account on commission basis; prefer a representative who is at present, and will continue, handling power plant equipment that does not compete with the high speed type engine. Box 421, POWER.

SITUATIONS WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

PRACTICAL GAS ENGINEER would take charge modern producer plant generators and refrigeration. Box 426, POWER.

SITUATION WANTED—Patternmaker foreman; age 43; experienced in electrical, engine, pump and shipyard work. Box 423, POWER.

ASSISTANT SUPERINTENDENT position; experienced on design and manufacture of gas and steam engines, pumps and general machinery. Box 418, POWER.

POSITION WANTED—Engineer with thorough knowledge of electricity, refrigerating and the economic production and distribution of steam; age 34. "Engineer," 5747 South Hermitage Ave., Chicago, Ill.

MISCELLANEOUS

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

PATENTS. C. L. Parker, Patent Attorney, ex-examiner Patent Office, 904 G St., Washington, D. C. Write for Inventor's Handbook.

SUBSCRIBE NOW for the 1911 issue of the Stationary Engineers' Directory of the city of Philadelphia; $5 per copy. Mail checks to Stationary Engineers' Club, 1108 Arch street, Philadelphia, Penn.

EVERY ENGINEER should be posted regarding the new system of vacuum heating installed without payment of royalty; I have valuable information; write today. T. L. Reeder, 1417 W. Jackson Blvd., Chicago, Ill.

$2.00 WILL BUY castings and all material for neatly designed automatic steam engine of 1/16 horsepower; engine has rotary valve with adjustment for wear; blueprints and instruction sheets 25 cents. Elgin Wheel & Engine Co., Dept. A, Elgin, Ill.

FOR SALE

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

FOR SALE—20x48 Wheelock engine and two 72"x18' high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

FOR SALE, going out of business—One recently purchased 10x10 Curtis double air compressor, fitted with unloader, air gage, tank piping, etc.; used less than 20 days; guaranteed perfect. Address "Compressor," Box 424, POWER.

FOR SALE—One five horsepower single phase, 60 cycle, 110-220 volt, 1750 r.p.m. Wagner motor; one 1 horsepower single phase, 60 cycle, 220 volt, 1750 r.p.m. Wagner motor; in perfect condition, used only a short time. Arthur T. Barlass, Chicago, Ill.

FOR SALE—One 75-horsepower Weber gas engine, direct connected to generator; one 120-horsepower Jacobson gas engine, belted; one 125-horsepower gas producer; one 160-horsepower gas producer, for anthracite coke; all in good condition and can be seen in operation. Box 417, POWER.

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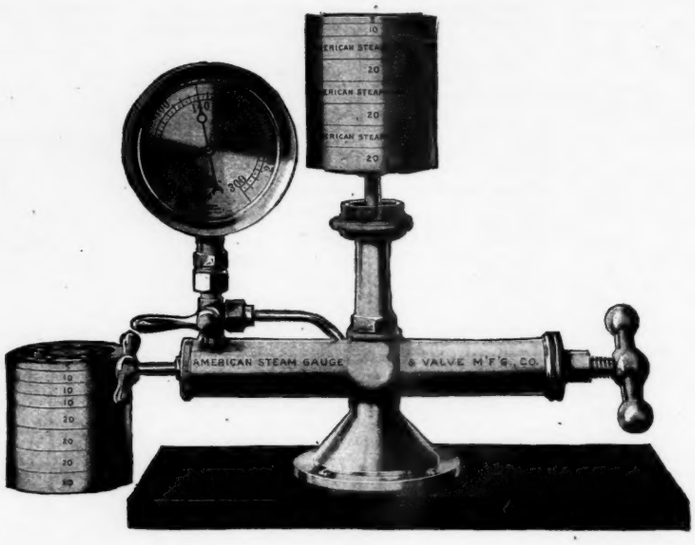

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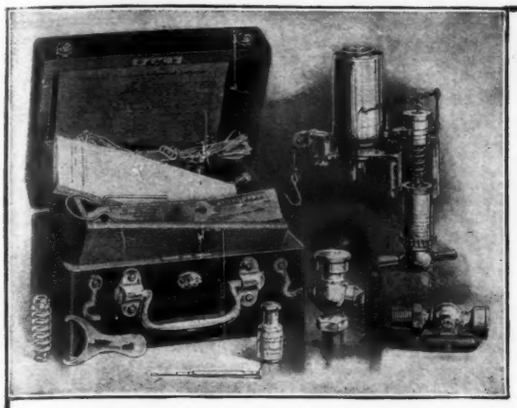

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100% Steam Plant Efficiency

Plant economy is not always best promoted by installing highly efficient, but costly, steam engines and turbines, nor by running auxiliaries condensing, nor by providing expensive electrical drive.

Wherever exhaust steam can be utilized for heating water for boiler feeding, or for industrial purposes, or for heating the building, or where the exhaust steam itself can be applied to such purposes, the engine or auxiliary to buy is a non-condensing one, and the one lowest in first cost and most reliable and satisfactory in operation.

If all the exhaust steam can be applied to heating purposes, the plant efficiency will come close to 100%, which is far above the most perfect utilization of heat possible when running condensing.

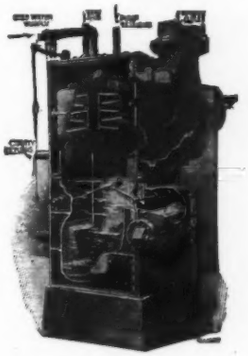
The energy generated by the prime mover is consumed as power and light within the building, and the heat radiated from the pipes, engines, pumps, etc., is retained by the air of the rooms, so that practically 100% of the heat of the steam is utilized.

The essentials to the practical utilization of exhaust steam are convenient and efficient appliances

(1) for removing the cylinder oil from the exhaust steam, and
(2) for utilizing the steam to heat boiler feed water.

Such appliances are found in the **Cochrane Oil Separator and Cochrane Open Feed Water Heaters, and Feed Water Heaters and Receivers.**

Where the surplus exhaust steam is to be used in a heating or drying system, the most convenient, compact and efficient apparatus is the improved **Cochrane Steam-Stack and Cut-Out Valve Heater and Receiver.**



Cochrane Steam Stack and Cut-Out Valve Heater and Receiver.

This apparatus combines the functions of a Cochrane Feed Water Heater and Receiver, and of a Cochrane Oil Separator of sufficient capacity to handle **all** the steam exhausted by the engines and auxiliaries.

It is so arranged that the separator, and the trap which drains the separator and the heater, may be cut out of communication with the heater, permitting the latter to be opened for inspection or cleaning while the separator continues in service.

This operation is carried out by two valves actuated from a single valve-gear, so that mistakes or oversight in the operation of the valve are impossible, preventing stalling of the engine, accumulation of high pressure in the heater, or scalding of attendants.

The Cochrane Steam-Stack and Cut-Out Valve Heater and Receiver is therefore FOOL-PROOF; it will improve any exhaust steam heating or drying system, it will save from $50 to $500 on the cost of equipping the plant, as compared with a plain heater and receiver with an oil separator installed in a by-pass, and it is fully protected by patents.

If you are interested in the utilization of exhaust steam for heating or drying purposes, write for a copy of our "*Exhaust Steam Heating Encyclopedia.*"

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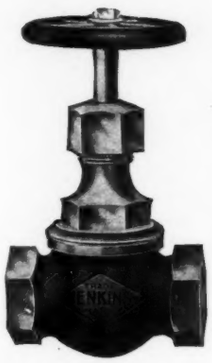

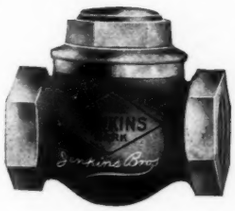

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